

NASA SP-7009 (01)



# LASERS AND MASERS

A CONTINUING BIBLIOGRAPHY  
WITH INDEXES

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# **LASERS AND MASERS**

## **A CONTINUING BIBLIOGRAPHY WITH INDEXES**

**A Selection of Annotated References to Un-  
classified Reports and Journal Articles intro-  
duced into the NASA Information System  
during the period February, 1965–April, 1966.**



*Scientific and Technical Information Division*

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

**WASHINGTON, D.C. JULY 1966**

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# Introduction

With the publication of this first supplement to the Continuing Bibliography entitled "Lasers and Masers", NASA SP-7009, the National Aeronautics and Space Administration continues its program of distributing selected references to reports and articles on aerospace subjects that are currently receiving intensive study. All references have been announced in either *Scientific and Technical Aerospace Reports* (STAR), *International Aerospace Abstracts* (IAA), or the NASA Continuing Bibliography *Aerospace Medicine and Biology* (NASA SP-7011 and its supplements). They are assembled in this bibliography to provide a reliable and convenient source of information for use by scientists and engineers who require this kind of specialized compilation. In order to assure that the distribution of this information is sustained, Continuing Bibliographies are updated periodically through the publication of supplements which can be appended to the original issue.

The scope of coverage of this supplement, NASA SP-7009 (01), is extensive, and references to all major studies associated with the research on, and development of, lasers and masers are included. Special emphasis is given to laser and maser applications as they relate to ranging and communications systems, astronomy and optics, and metalworking. Pertinent references to fundamental studies devoted to the physical and electronic properties of lasers and masers, as well as their function and performance, will also be found in this collection.

Each entry in the bibliography consists of a citation and an abstract. The listing of entries is arranged in two major groups. Report literature references are contained in the first group and are subdivided according to their date of announcement in STAR. The second group includes published literature references, subdivided according to their date of announcement in IAA, or in *Aerospace Medicine and Biology*. All reports and articles cited were introduced into the NASA information system during the period February, 1965–April, 1966.

A subject index and a personal author index are included.

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*(continued)*

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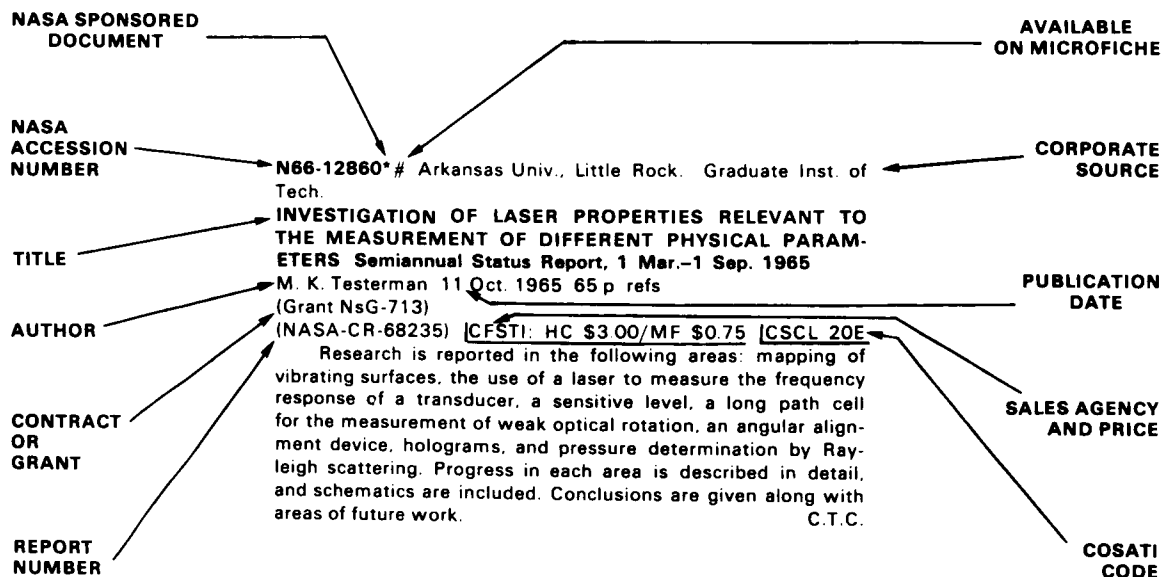
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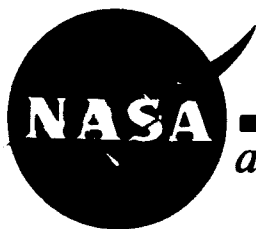
Articles listed are available in the journals in which they appeared. They may be borrowed or consulted in libraries maintaining sets of these journals. In some instances, reprints may be available from the journal offices.

# TABLE OF CONTENTS

	Page
1965 STAR Entries (N65 Series) . . . . .	1
1966 STAR Entries (N66 Series) . . . . .	47
1965 IAA Entries (A65 Series) . . . . .	71
1966 IAA Entries (A66 Series) . . . . .	151
1966 LC Entries (A80 Series) . . . . .	211
Subject Index. . . . .	I-1
Personal Author Index. . . . .	I-137

## TYPICAL CITATION AND ABSTRACT





# Lasers and Masers

*a continuing bibliography with indexes* JULY 1966

## 1965 STAR ENTRIES

**N65-13558\*** Hughes Research Labs., Malibu, Calif.  
**DESIGN AND CONSTRUCTION OF AMMONIA BEAM MASER** Technical Summary Report  
J. L. Walsh Apr. 1962 39 p  
(Contract NASw-62)  
(NASA-CR-55839) OTS: HC \$2.00/MF \$0.50

This report describes the construction of two ammonia beam masers and associated frequency translators which demonstrate, under laboratory conditions, a long-term frequency stability of better than one part in  $10^{10}$ . The masers utilize two critically coupled cavities in order to minimize frequency pulling effects due to cavity drift. The cavities are separated by  $9/4$  wavelengths and are both tuned to the maser frequency. This configuration produces a minimum phase shift (due to cavity drift, etc.) of the resonant cavity system as seen by the ammonia beam. The masers incorporate a point source and tapered focuser and operate with  $N^{15}H_3$  derived from a chemical source, which affords excellent beam stability. Associated with each maser is a frequency translator consisting of a 52.7 Mc crystal, whose output is multiplied and phase locked to the maser output, thus providing signals with maser stability at frequencies in a more useful part of the rf spectrum. Author

**N65-13790#** Columbia U., N.Y. Columbia Radiation Lab.  
**THE OPTICAL MASER APPLIED TO BRILLOUIN SCATTERING SPECTROSCOPY** Progress Report, 1 Oct. 1963-31 Mar. 1964  
R. Novick Apr. 1964 3 p refs  
(Contract DA-ARO(D)-31-124-0380)  
(PR-3; AD-605736)

Measurements of linewidth of Rayleigh scattering due to diffusion were completed. Small discrepancies between theory and experimental data were traced to Doppler shift effects produced by thermal convection in the solvent, and were subsequently eliminated. In an auxiliary experiment, this same Doppler effect was studied with the solvent current controlled mechanically. Results indicate that this effect can be used as a technique in fluid flow measurements. A  $Hg^+$  laser was constructed and operated in a pulsed mode. Another structure with a 2.5-mm-bore discharge tube was completed. Continuous-wave laser action is being attempted with this design. R.L.K.

**N65-13857\*** International Business Machines Corp., Poughkeepsie, N.Y. Development Labs.  
**USE OF OPTICAL MASERS IN DISPLAYS AND PRINTERS** Fourth Quarterly Report, 24 May-23 Aug. 1964  
W. Kulicke, K. Kosanke, E. Max, and H. Fleisher [1964] 42 p refs  
(Contract DA-36-039-AMC-00118(E))  
(Rept.-6; AD-452259)

The evaluation of specifications of the deflector was continued. This includes the influence of temperature on the splitting angle between ordinary and extraordinary rays in the birefringent elements. It also includes an analytical evaluation of the influence of fabrication tolerances and bandwidth of light on the background light. Compensation of focal depth into the deflector affects the distribution of background light. The effect is discussed for various methods of compensation. Birefringent calcite crystals were cemented successfully; results are reported. A lens system for widening the laser beam to the full aperture of the deflector and for focusing the beam to the output plane is specified. Further investigations refer to the problem of electroding the electro-optic crystals. One of the suggested electronic switches for high-speed, low-power operation—the second harmonic phase modulated switch—was investigated. The experiments were performed at different speeds and voltages with promising results. Author

**N65-13904** Joint Publications Research Service, Washington, D.C.  
**INVESTIGATION OF MASER WITH TWO SERIES RESONATORS**  
E. M. Belenov and A. N. Orayevskiy *In its Izv. VUZov: Radio-phys.*, vol. VII, no. 3, 1964 25 Nov. 1964 p 125-143 refs  
(See N65-13892 04-07) OTS: \$6.00

In a maser using two series resonators it is possible to maintain oscillations such that the width of the radiation line is determined, fundamentally, by the transit time between the resonators. Here, there is a considerable reduction in the influence of the traveling-wave effect on oscillation frequency. The limit of stability for this type of mode depends on the parameters of the device. Author

**N65-14074#** Lightning and Transients Research Inst., Minneapolis, Minn.  
**LASER TYPE ULTRA-VIOLET RADIATION FEASIBILITY FOR LIGHTNING AND ATMOSPHERIC PROPAGATION STUDIES, PART II** Final Report  
J. R. Stahmann Oct. 1964 25 p refs  
(Contract AF 19(604)-7984)  
(L&T-417; AFCRL-64-859, Pt. II; AD-609217)

Laboratory experiments were limited to the use of a 14-kW carbon arc as a source in the far ultraviolet. No long spark diversion similar to that found with a jet plasma ( $10^7$  to  $10^8$  ions/cc) was observed with the carbon arc source. Methods of selective ionization to distribute the ions over the beam with just the density required for the conductivity of a jet plasma include possible rocket distribution of combustible particles to

be ignited by a conventional laser beam for distances of several miles.  
Author

**N65-14185#** Perkin-Elmer Corp., Norwalk, Conn. Electro-Optical Div.

**RESEARCH INTO THE CAUSES OF LASER DAMAGE TO OPTICAL COMPONENTS First Quarterly Report, 1 Mar.-31 May 1964**

G. N. Steinberg [1964] 53 p refs /Its Rept.-7735  
(Contract DA-28-043-AMC-00009)  
(PE-TR-7735; AD-450188)

Instruments and techniques are described by which a known and controllable Q-switched laser illumination level was obtained. This light was then used for determining the damage threshold of specially prepared dielectric mirrors and for creating internal damage in optical glass. Presentation is made of the data obtained from the experiments using the techniques described.  
Author

**N65-14200#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

**RESONANT ENERGY TRANSFER FROM MERCURY TO ZINC IN RELATION TO A GAS LASER**

Robert Mason Howard, Jr. (M.S. Thesis) Aug. 1964 71 p refs  
(AD-603680) OTS: \$3.00

An electronic system was constructed for scanning the spectral output of a Jarrell Ash spectrograph. This was used to observe the spectrum of an Hg-Zn discharge which originated from a heated dc glow discharge tube in which the partial pressures of Zn and Hg could be varied independently. Observations of the spectra indicate a resonant energy transfer from the  $7^3S_1$  state of Hg to the  $4^3D_1$  state of Zn at high voltages across the tube (anode to cathode). At lower voltages the  $7^3S_1$  Hg state couples to the  $4^1D_2$  state of Zn and indicates that a population inversion might be achieved in the Zn between the  $4^1D_2$  and  $4^1P_1$  state.  
Author

**N65-14217#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**WIDTH OF LINES EMITTED BY LASER MODELS**

V. S. Mashkevich 26 Oct. 1964 7 p refs Transl. into ENGLISH from Ukr. Fiz. Zh. (Kiev), v. 8, no. 8, 1963 p 918-921  
(FTD-TT-64-841/1; AD-608179)

Kinetic equations are used to investigate the stationary conditions of a laser. Solutions of Maxwell equations with approximate boundary conditions are discussed and applied to a consideration of the effect of line narrowing in a laser.  
P.V.E.

**N65-14311#** Philco Corp., Blue Bell, Pa. Research Lab.  
**COHERENT OPTICAL PARAMETRIC TECHNIQUES First Quarterly Report**

C. Wang Griffiss AFB, N.Y., RADC, Oct. 1964 20 p refs  
(Contract AF 30(602)-3364)  
(RADC-TDR-64-386; AD-608921)

The theoretical and experimental aspects of optical parametric amplification involving three waves were studied. Major achievements include (1) successful operation of high power, nearly single-moded ruby lasers, and (2) observation of parametric interaction among Raman-shifted lines. An attempt is being made to observe parametric amplification of the 6328 Å radiation from He-Ne gas laser, using the second harmonic radiation of ruby as the pump.  
Author

**N65-14365#** Litton Industries, San Carlos, Calif. Electron Tube Div.

**PLASMA-POWERED COHERENT OPTICAL TRANSMITTER Final Report, Jul. 1963-Aug. 1964**

Gerold Pokorny, Joseph Stafford, Gerald Secrest, Gerald Cox, and James Clauss 30 Oct. 1964 44 p refs  
(Contract AF 33(657)-11399)  
(DORF-173; AL-TDR-64-257; AD-450741)

This report covers work on the development of a high intensity uv source centered at 254 mμ with spectral output of less than 1 mμ. The uv source is used to pump phosphors which in turn pump laser materials which have absorption bands in the emission spectrum of the phosphor. The uv source can also be used to directly pump laser materials where they efficiently absorb at 254 nm. An experimental study of the mercury discharge mechanism and phosphor efficiency was accomplished. The lack of a commercially available spectral radiometer in the uv region made it necessary to build and calibrate one for the program. Following the evaluation of the discharge and phosphors, a laser pump was constructed to try the uv phosphor technique on an Nd<sup>3+</sup> doped CaWO<sub>4</sub> crystal.  
Author

**N65-14369** Stanford U., Calif. Stanford Electronics Labs.  
**TUNING OF CW LASERS OVER ANGSTROM BANDWIDTHS: SOME POSSIBLE APPROACHES Technical Report No. 0576-6**

R. J. Morris Aug. 1964 30 p refs  
(Contract AF 33(657)-11144)  
(SU-SEL-64-092; AL-TDR-64-227; AD-607852)

This report is an investigation of several approaches to the problem of obtaining cw coherent optical signals whose wavelength can be scanned in a controlled fashion over a range of approximately 1 Å or more. The methods discussed include the following internal tuning methods: Zeeman tuning; diffraction from acoustic waves; crystal-strain tuning; thermal tuning; tunable mode selection in wide lines; and doppler-shift tuning using a beam of accelerated particles. The last method listed is believed to be a novel scheme for laser tuning. Frequency modulation using microwave frequencies and large modulation indices is also discussed as an external tuning method.  
Author

**N65-14383#** Westinghouse Electric Corp., Baltimore, Md. Aerospace Div.

**DEVELOPMENT OF MILLIMETER AND SUBMILLIMETER MASER DEVICES Interim Technical Report, 1 Jun.-31 Oct. 1964**

W. E. Hughes [1964] 25 p refs /Its Rept.-490E  
(Contract AF 33(657)-10472)  
(ITR-5; AD-607983)

The major effort was devoted to the construction of a dual-channel millimeter-wave spectrometer, the testing of an Fe<sup>3+</sup>, ZnWO<sub>4</sub> zero-field maser, experiments on an Fe<sup>3+</sup>, TiO<sub>2</sub> zero-field maser, and the construction of X-band maser circuitry. Each of the above program elements is described in detail, and the conclusions drawn from the experiments are given.  
Author

**N65-14405#** General Telephone and Electronics Labs., Inc., Bayside, N.Y.

**CHELATE LASERS Annual Technical Summary Report, 1 Oct. 1963-30 Sep. 1964**

A. Lempicki, H. Samelson, and C. Brecher 30 Oct. 1964 48 p refs  
(Contract Nonr-4134(00); ARPA Order 306-62; Proj. Defender)  
(TR-64-052.7; AD-450627)

Results of investigating the properties of chelates in terms of the requirements for laser action, and of studying the characteristics of the chelate laser itself are summarized. The investigations and studies led to the following conclusions: (1) Laser action can be obtained in a highly fluid medium at room temperature. Development of a laser with a circulating medium is indicated to be only a technological problem. (2) The study of the spectroscopy of chelates has revealed detailed information on the structure, symmetry, and stability of various compounds. It appears that four-ligand materials are superior



from the laser point of view. (3) The great flexibility of the chelate systems has been demonstrated by such effects as the "tuning" achieved by cation addition and the variety of solvent influences. P.V.E.

**N65-14437#** Radio Corp. of America, Princeton, N.J. RCA Labs

**INTERACTIONS OF COHERENT OPTICAL RADIATION WITH SOLIDS Final Report**

R. Braunstein and N. Ockman 31 Aug. 1964 70 p refs  
(Contract Nonr-4128(00); ARPA Order 306-62; Proj. Defender)  
(AD-450756)

The following are discussed: (1) optical two-phonon absorption in semiconductors; (2) second-harmonic generation in the III-V compounds InP, GaAs, AlSb, and GaP; (3) frequency mixing in such semiconductors as Ge, GaAs, and Si; and (4) the frequency tuning of injection lasers by uniaxial stress. Included as appendices are the following papers: (1) *Optical Double-Photon Absorption in CdS*; (2) *Frequency Tuning of GaAs Laser Diode by Uniaxial Stress*; and (3) *Effect of Doping on the Emission Peak and Absorption Edge of GaAs*.

E.K.R.

**N65-14446#** Navy Electronics Lab., San Diego, Calif.  
**A VERSATILE EIGHT-METER GAS LASER SYSTEM Research Report, Dec. 1962-Mar. 1964**

V. N. Smiley and A. L. Lewis 28 Sep. 1964 21 p refs  
(NEL-1242; AD-607969)

An 8-meter-long, versatile gas laser and associated equipment were designed and constructed, employing three methods of excitation (60-c/s ac, dc, and rf) and a Brewster-angle prism method of intracavity wavelength selection. The high gain resulting from the extreme length of the laser facilitated the finding of previously unreported laser lines in the infrared. A novel method of facilitating the alignment of mirrors, making use of the 3.39-micron He-Ne line, was utilized. Calculations of reflectance for light polarized parallel to the plane of incidence for small deviations from the Brewster angle are given for an air-quartz interface. Author

**N65-14460#** Harry Diamond Labs., Washington, D.C.  
**RANGEMETER FOR XM23 LASER RANGEFINDER, MODEL II**

Ira R. Marcus 16 Nov. 1964 44 p ref  
(HDL-TR-1262; AD-452838)

A modified rangemeter, designated model II, was constructed and determined capable for use with the XM23 Laser Rangefinder. The model II design is a high-speed, miniature, digital time-interval counter that displays range readings from 200 to 19995 meters when coupled to the rangefinder. This range capability is twice that of the model I rangemeter. Another advantage of the model II design is that it includes a target counter, thus allowing the operator to range on any one of five target echoes. Operation of the rangemeter is based on start-and-stop pulses that are received from the rangefinder. The counter then computes and displays the range to the nearest  $5 \pm 5$  m on a solid-state electroluminescent readout. The readout assembly is optically coupled between the computing circuits and a photoconductive readout matrix. The rangemeter system operates from  $-55^\circ$  to  $+75^\circ$  C with a 5- to 7-V supply. The time base is a 29.971-Mc crystal oscillator; the computing circuits are high-frequency flip-flops. Author

**N65-14465#** Korad Corp., Santa Monica, Calif.  
**SOLID STATE LASER AMPLIFIER Quarterly Report, 1 Jun.-31 Aug. 1964**

A. H. Gillmer, R. C. Pastor, and H. Schultz Sep. 1964 34 p refs  
(Contract DA-36-039-AMC-00070(E))  
(QR-6; AD-453191)

The theory of gain measurements together with experimental results were reported. Deterioration of rubies was

described, and means for inhibiting the damage were developed. In this report, further gain measurements are presented. Development of spiking free lasers, both by mode control and by feedback control, is presented. It is intended to amplify the spiking free pulse to obtain a high-energy pulse in the micro-second and millisecond time scales. Author

**N65-14531\*#** Massachusetts Inst. of Tech., Cambridge.  
**COHERENTLY DRIVEN MOLECULAR VIBRATIONS AND LIGHT MODULATIONS**

E. Garmire, F. Pandarese, and C. H. Townes [1963] 9 p refs  
Submitted for Publication  
(Grant NSG-330)

(NASA-CR-56211) OTS: HC \$1.00/MF \$0.50

Very intense maser beams in dense matter produce higher order Raman effects through excitation of intense coherent molecular oscillations at infrared frequencies. These modulate the original light and its Raman-scattered radiation producing Stokes and anti-Stokes lines of many orders, frequently without a threshold condition for generation and in some cases with highly directional radiation patterns. Theory is developed for these Raman effects and conclusions (some of which correspond to experimental observations) are presented. E.W.

**N65-14941#** Naval Training Device Center, Port Washington, N.Y. Human Factors Lab.

**BIOLOGICAL EFFECTS OF LASERS: SAFETY RECOMMENDATIONS AND A COMMENT ON THE CONCEPT OF OCULAR DAMAGE**

Paul A. Cirincione 28 Jul. 1964 13 p refs  
(NAVTRADEVCE-1H-15; AD-607718)

Since lasers are being increasingly employed and because the laser beam is the most intense artificial light available, questions concerning health hazards to personnel become most important. Several of the most prominent effects, the concept of ocular damage, and proposed safety procedures are presented. The following safety rules are given for laser work: (1) Laser laboratories should be clearly marked as eye hazardous areas. (2) All laser light, regardless of the nature of the laser, should be considered dangerous. (3) Laser laboratories should be brilliantly illuminated to constrict the size of the pupil of the eye. (4) Protective goggles such as the Jena color glass should be worn by all personnel. (5) Interlock systems should be incorporated into lasers so they will not function if anyone is in the light path. E.E.B.

**N65-14982#** Ohio State U. Research Foundation, Columbus. Antenna Lab.

**CHARACTERISTICS OF VISIBLE DISCHARGES INDUCED IN GASES BY FOCUSED RUBY LASER PULSES**

R. G. Tomlinson (Ph.D. Thesis) 1 Sep. 1964 108 p refs  
(Contract AF 33(657)-10824)  
(Rept.-1579-14; AD-449441)

The focused radiation from a high brightness laser can produce power densities which result in sufficient ionization in gases to cause breakdown in the form of visible discharges. A high brightness, Q-switched ruby laser was constructed and used to study the characteristics of these visible discharges. Data were taken in krypton, argon, helium, neon, air, nitrogen, oxygen, methane, and carbon dioxide as a function of pressure and laser power density. Focusing lenses with 3-cm and 1.2-cm focal lengths were employed. A comparison of the experimentally determined laser ionization rates with the micro-wave ionization rates was made through the scaling factor, effective electric-field strength. The laser-induced ionization

rates were much greater than the microwave ionization rates, indicating a more efficient energy coupling mechanisms. When threshold conditions were exceeded the density of free electrons in the gas grew rapidly in a cascade process to produce a visible breakdown plasma and shock wave. Author

**N65-15207** United Aircraft Corp., East Hartford, Conn. Research Labs

**ULTRASONIC CONTROL OF LASER PERFORMANCE** Final Report, Jun. 26, 1963-Jun. 25, 1964

A. J. De Maria and G. E. Danielson, Jr. 25 Sep. 1964 33 p refs (Contract DA-19-020-AMC-0170(A)) (C-920083-12; AD-605940)

The laser is represented in terms of a system block diagram having forward and feedback transfer functions which can be varied in a periodic manner so as to modulate the output of the quantum device. The modification of a laser's feedback transfer function by an ultrasonic refraction and by an optical-tunnelling shutter has been utilized to gate the laser's output. Experiments are reported which demonstrate that the periodic fluctuation of the refractive index resulting from the propagation of focused ultrasonic energy within a solid-state laser medium can be utilized as a Q-spoiler to gate the output of high gain lasers without the introduction of lossy elements into the laser's feedback path. In addition, experiments are reported which reveal an increase in the energy output of a neodymium-doped lanthanum thorium borate glass rod when longitudinal acoustical standing waves were propagated down the length of the glass rod. Author

**N65-15259#** Sperry Gyroscope Co., Great Neck, N.Y. Electro-Optics Group

**INVESTIGATION OF OPTICAL FREQUENCY TRANSLATION TECHNIQUES**

J. K. Sharp, E. O. Vaher, and E. W. Cheatham, ed. Wright-Patterson AFB, Ohio, AF Avionics Lab., Sep. 1964 72 p (Contract AF 33(657)-11653)

(AB-1272-0013; AL-TDR-64-226; AD-607700) OTS: \$3.00

Various techniques of optical frequency translation were investigated, leading to the design of a V-shaped laser configuration that can simultaneously support independent oscillations having two separate polarizations. The device consists of two laser cavities sharing a single neodymium-doped glass laser rod and end mirror. Theoretical and experimental studies of mode selection techniques and Fabry-Perot interferometric analyzers are presented. This work leads to single-mode operation for each separate frequency and to effective methods of measuring translation. Tuning a single leg of the Y laser, translation over a total range of 18 Gc was achieved. Observation of simultaneous operation of both legs was also made. It was concluded that the method selected was feasible and that further effort is warranted. Author

**N65-15502#** General Telephone and Electronics Labs., Inc., Bayside, N.Y.

**CONFERENCE ON ORGANIC LASERS**

25 May 1964 228 p refs Conf. held at Bayside, N.Y., 25 May 1964; sponsored jointly with ONR (Proj. Defender)

(TR-64-052.6; AD-447468)

**CONTENTS:**

1. THE ORGANIC LASER A. Lempicki p 5-15 refs (See N65-15503 06-16)

2. STIMULATED EMISSION CONSIDERATIONS IN FLUORESCENT ORGANIC MOLECULES D. L. Stockman (Gen. Elec. Co.) p 16-39 refs (See N65-15504 06-16)

3. RECENT RESULTS ON ENERGY TRANSFER IN

RARE EARTH CHELATES M. Kleinerman (Am. Optical Co.) p 39-57 (See N65-15505 06-24)

4. EXCITONS AND TWO QUANTA PROCESSES IN MOLECULAR CRYSTALS R. M. Hochstrasser (Pennsylvania U.) p 58-71 refs (See N65-15506 06-26)

5. STIMULATED EMISSION IN ISOTOPICALLY MIXED BENZENE CRYSTALS D. S. Tinti and G. W. Robinson (Calif. Inst. of Tech.) p 72-90 (See N65-15507 06-26)

6. THE RARE EARTH CHELATE LASERS C. Brecker, H. Samelson, A. Lempicki, and V. A. Brophy p 91-109 refs (See N65-15508 06-16)

**N65-15503** General Telephone and Electronics Labs., Inc., Bayside, N.Y.

**THE ORGANIC LASER**

A. Lempicki *In its* Conf. on Org. Lasers 25 May 1964 p 5-15 refs (See N65-15502 06-16)

The problems connected with the development of a purely organic laser are discussed. Pump requirements are compared for three types of laser systems: phosphorescent materials, such as benzophenone; existing ruby and chelate lasers; and fluorescent materials, such as anthracene and mixed crystals. R.L.K.

**N65-15504** General Electric Co., Syracuse, N.Y. Electronics Lab.

**STIMULATED EMISSION CONSIDERATIONS IN FLUORESCENT ORGANIC MOLECULES**

David L. Stockman *In* Gen. Telephone and Electron. Labs. Conf. on Org. Lasers 25 May 1964 p 16-39 refs (See N65-15502 06-16)

The reasons for choosing fluorescent instead of phosphorescent compounds in developing an organic laser are discussed. Two promising molecules studied are perylene and 9-aminoacridine. The properties of liquid and polymeric resonant cavities formed with the organic host materials were investigated. Experimental results indicated that a pumped liquid resonant cavity at room temperature employing nonviscous liquids can be operated for about 30  $\mu$ sec without increasing scattering losses to unbearable limits. For polymeric host materials, birefringence is being studied as a function of wavelength in the samples to determine the exact composition required to yield a zero stress optical coefficient at the wavelength of interest. Several approaches to the problem of generating sufficient peak power in a short time were made, the most promising pumping source being an argon theta-pinch lamp. The results of some pumping experiments are described. R.L.K.

**N65-15505** American Optical Co., Southbridge, Mass. **RECENT RESULTS ON ENERGY TRANSFER IN RARE EARTH CHELATES**

M. Kleinerman *In* Gen. Telephone and Electron. Labs. Conf. on Org. Lasers 25 May 1964 p 39-57 (See N65-15502 06-16)

A postulated mechanism of energy transfer in lanthanide chelates, which involves a participation of the triplet level of the chelates, is criticized, and the implications for organic laser design are discussed. Reviewed are the problems of fluorescence efficiency and the high-absorption coefficient of the ligands in laser application of rare-earth chelates. R.L.K.

**N65-15508** General Telephone and Electronics Labs., Inc., Bayside, N.Y.

**THE RARE EARTH CHELATE LASERS**

C. Brecher, H. Samelson, A. Lempicki, and V. A. Brophy *In its* Conf. on Org. Lasers 25 May 1964 p 91-109 refs (See N65-15502 06-16)

The achievement of lasing in benzoylacetate and dibenzoylmethide chelates of europium, and the problems of getting these materials to lase, are described. The DBM chelate, unlike the benzoylacetate, does not lase in an alcohol solution, but the addition of small amounts of dimethylformamide to the solvent enables laser action to take place, showing the great effect of chemical changes on the characteristics of the emission. Chemical preparation methods for various materials can lead to 3-ligand and 4-ligand forms of chelates. The possible structures of the 4-ligand form are discussed. Other chemical problems reviewed include the extremely intense absorption of chelates. Where the absorption constant is too low, little energy can be absorbed; where the absorption constant is too high, little energy can reach the center of the cell to be absorbed.

R.L.K.

**N65-15565#** Naval Ordnance Lab., Corona, Calif.  
**FOUNDATIONAL RESEARCH PROJECTS Quarterly Report,**  
 Jan.-Mar. 1963

C. J. Humphreys 1 Jun. 1963 87 p refs  
 (NAVWEPS-8150, AD-409856)

#### CONTENTS

1. THIN MAGNETIC FILM PARAMETRONS R. L. King and J. H. Johnson p 1-6 (See N65-15566 06-09)
2. SYNTHETIC STUDIES D. L. Herring and C. M. Douglas p 7-19 refs (See N65-15567 06-06)
3. POLYMERIZATION MECHANISM STUDIES K. L. Paciorek and R. H. Kratzer p 20-31 (See N65-15568 06-06)
4. THE FIRST SPECTRUM OF XENON IN THE 4-MICRON REGION AND ITS INTERPRETATION C. J. Humphreys and E. Paul, Jr. p 33-39 refs (See N65-15569 06-23)
5. LASERS R. L. Conger, J. H. Johnson, L. T. Long, and J. A. Parks p 41-45 (See N65-15570 06-16)
6. THE ELECTROREDUCTION OF SUBSTITUTED AROMATIC NITRO COMPOUNDS IN LIQUID AMMONIA SOLUTIONS W. S. Harris p 47-49 (See N65-15571 06-06)
7. IONIC MELT ELECTROCHEMISTRY R. E. Panzer p 50-57 refs (See N65-15572 06-06)
8. NARROW PULSE GENERATION BY NONLINEAR TRANSMISSION LINE METHODS J. R. Alday p 59-76 refs (See N65-15573 06-10)
9. EDGE SHIFT AND  $m_e^*$  IN GaSb AS A FUNCTION OF FERMI LEVEL H. Piller, V. A. Patton, and G. Zaeschmar p 77-84 refs (See N65-15574 06-26)
10. INFRARED ABSORPTION SPECTRUM OF  $Ce^{3+}$  IN  $LaF_3$  R. A. Buchanan, J. Murphy, and H. H. Caspers p 85-90 refs (See N65-15575 06-26)

**N65-15570** Naval Ordnance Lab., Corona, Calif.  
**LASERS**

R. L. Conger, J. H. Johnson, L. T. Long, and J. A. Parks *In its Foundational Res. Proj.* 1 Jun. 1963 p 41-45 (See N65-15565 06-34)

The observation by means of a phototube of the output of a ruby laser as a function of time is reported. A beam-width spread of  $0.5^\circ$  was reduced with a telescope to  $0.07^\circ$ , and it is suggested that this spread could be reduced to  $0.02^\circ$  with more refined apparatus and adjustments. A calorimetric determination of laser efficiency showed an efficiency of about 0.01%. This may be accounted for by xenon tube efficiency, low coupling between flash tube and ruby, nonradiative energy dissipation in the ruby, and nonradiative portions of the ruby. Pyrotechnics were investigated as possible pumping light sources, and it was concluded that pyrotechnic bombs are of no merit in laser experiments, because they produce less light than flash bulbs and have the disadvantages of noise and smoke.

D.E.W.

**N65-15605#** Stanford U., Calif. Microwave Lab.  
**RESEARCH AND INVESTIGATION OF SELECTED MICRO-WAVE PROBLEMS Interim Engineering Report No. 6, 1 Jun-31 Aug. 1964**

Oct. 1964 15 p refs  
 (Contract AF 33(657)-11042)  
 (ML-1243; AD-451327)

The following studies were made: (1) *Acoustic-Wave Interactions*—the current oscillations in a CdS single-crystal diode, the diffracting properties of ADP, and the diffraction of a pulsed ruby laser beam by sound modulation at 10 kc; (2) *Transverse-Wave Devices*—a periodic parallel-plate or twisted dc coupler to be used for the deflection of longitudinal velocity spread of electron beams; (3) *Optical Spectroscopy of Laser Materials*—the construction of an irradiator for the testing of solid materials for laser action in the ultraviolet and visible regions; and (4) *Nonlinear Quantum Studies*—the insertion of a KDP crystal modulator into a ruby laser cavity to generate a second harmonic mode.

G.G.

**N65-15753#** New Mexico State U., University Park, Research Center

**VARIATION OF REFRACTIVE INDEX DURING LASER OPERATION Semiannual Technical Report**

J. R. Izatt, H. A. Daw, and R. C. Mitchell Jan. 1964 27 p refs  
 (Contract Nonr-3531(04))  
 (SATR-1; AD-427725)

Variation in refractive index as a function of the distribution of population among pertinent energy states can be studied experimentally by using a laser as a source with which to illuminate a sample of the same material. The latter is optically pumped to achieve a sequence of non-Boltzmann population distributions, and an interferometric technique is employed to determine refractive index as a function of frequency for each distribution. Temperature control or other means are used to scan the output of the source laser in frequency. A brief discussion of theoretical considerations is given as is a detailed description of the basic experimental techniques. Several items of equipment are described which were designed and constructed to partially fill the optical pumping and temperature control requirements of the experiment. A unique cast-plastic optical-pump cavity is described which has displayed high optical efficiency in addition to being durable and economical.

Author

**N65-15848#** Korad Corp., Santa Monica, Calif.  
**LASER MATERIALS RESEARCH. PART I: RUBY IMPROVEMENT Final Report**

R. C. Pastor and R. H. Hoskins Sep. 1964 123 p refs  
 (Contract AF 33(657)-11395)  
 (AL-TDR-64-195, Pt. 1; AD-608105) OTS: \$4.00

The objective of this laser research program was the improvement of the crystal quality of Verneuil (flame fusion) ruby. The study was directed toward the overall achievement of a steady-state operation of this method of crystal growth. New approaches to the materials problems, experimental techniques, and results obtained are presented. Various subsidiary processes were investigated, with respect to a steady-state operation. Useful experimental parameters relevant to the successful matching of auxiliary processes are discussed.

Author

**N65-15881#** General Electric Co., Syracuse, N.Y. Heavy Military Electronics Dept.

**SEMICONDUCTOR LASER AMPLIFIER TECHNIQUES (SEMLAM) Final Report**

Griffiss AFB, N.Y., RADC, Oct. 1964 41 p refs  
 (Contract AF 30(602)-3111)  
 (RADC-TDR-64-384; AD-609704)

This report contains information on the work done in the semiconductor laser amplifier program. A transmission-type light amplifier was successfully tested. The system used consists of a light-emitting GaAs diode, with SiO antireflection coated Fabry-Perot surfaces, as an amplifier and a cw oxygen gas laser as an oscillator. A gain of 15 dB from the gas laser beam was observed. Author

**N65-15980#** Raytheon Co., Waltham, Mass. Research Div. **GASEOUS LASER RESEARCH** Interim Engineering Report No. 2, Aug. 1-Oct. 31, 1964

F. Horrigan, S. Koozekanani, and R. Tataronis Wright-Patterson AFB, Ohio, Res. and Technol. Div. [1964] 48 p refs (Contract AF 33(615)-1949) (S-705; AD-608635)

Combining the results of the lifetime and cross-section considerations, a general explanation for the properties of a discharge-excited laser system were developed. This involves nonselective excitation by the electrons followed by multiple cascading from the higher excited states into the lower sets of levels. To investigate the hypothesis in more detail, an extensive computer study of a simplified 40-level system is in the process of preparation, utilizing Bates-Damgaard lifetimes and reasonably constructed cross sections. A complete description of this program is given. No numerical results are as yet available. Difficulties with the electron beam focusing still remain the largest obstacle in the experimental program for the measurement of electron excitation cross sections in xenon. Several preliminary cross-section measurements are presented. It is concluded that multiple cascading must be playing an important role in xenon. Author

**N65-16002#** Air Force Cambridge Research Labs., Bedford, Mass. Optical Physics Lab.

**APPLICATIONS OF LASERS**

C. Martin Stickley Nov. 1964 43 p refs /Its Spec. Rept. No. 15 (AFCLR-64-914; AD-609846)

This article is a survey of applications of lasers. The applications are divided into six major areas: precision measurements, communications, biological and medical, other scientific areas, metalworking, and miscellaneous. A table of the basic characteristics of the major types of lasers is provided, so that the user can be made aware of the limitations and capabilities of lasers. Good examples of applications in each of these areas are described in some detail to illustrate which major properties of laser radiation are useful in that particular area. Most of the discussion pertains to present-day applications, but in some instances what appear to be good future applications are also described. Seventy-two references to the technical literature that relate to applications are provided. Author

**N65-16013#** Electro-Optical Systems, Inc., Pasadena, Calif. **OPTICAL TRANSMITTER TECHNIQUES** Technical Documentary Report, 15 Apr.-15 Jul. 1964

D. B. Bowen et al. Griffiss AFB, N.Y., RADC, Dec. 1964 58 p refs /Its Rept. 5180-Q-1 (Contract AF 30(602)-3440) (RADC-TDR-64-442; AD-610106)

This report describes work directed toward the design and fabrication of a gas laser oscillator and a solid-state chelate laser operating at wavelengths ranging from  $5.0\mu$  to  $0.3\mu$ . New classes of sensitized fluorescence and their sensitizers were investigated, and system efficiency was improved through sensitizer purification. Some of the new sensitized systems investigated show promise of operation at or above room temperature. The scientific basis for sensitized fluorescence is clarified through a detailed analysis and description of the

mechanism of energy transfer. Appropriate laser calculations and optimization were accomplished and associated laser test cavities, heat exchangers, and other equipment were built in preparation for testing the new materials. Author

**N65-16017#** Cutler-Hammer, Inc., Deer Park, N.Y. Airborne Instruments Lab.

**STUDY OF SOLID-STATE AND TRAVELING-WAVE MASER TECHNIQUES** Interim Report

J. A. De Gruyl, W. W. Heinz, S. Okwit, and J. G. Smith Griffiss AFB, N.Y. RADC, Jan. 1965 48 p refs (Contract AF 30(602)-2989) (RADC-TDR-64-480; AD-610317)

The purpose is to develop improved maser techniques and apply them to a broadband maser system. Magnetic shimming techniques capable of providing the proper field gradients in a superconducting solenoid were successfully tested. The analysis of broadbanding was extended to include the effects of non-ideal magnetic field gradients and rf field distributions in the TWM structure. Correlation between theory and experiment is now much improved, facilitating the evaluation and application of these techniques to a deliverable breadboard. Limiting characteristics in a broadband stripline semiconductor limiter at  $4.2^\circ$  K were obtained. Techniques to decrease the limiting by using a more resonant, ridged waveguide structure are being developed. An analysis of a fine-wire superconducting limiter indicates that the operating bandwidth of such a device would be too narrow for the intended application. An analysis of the feasibility of superconducting thin-film tunneling techniques as a pump source for masers was completed and is presented. The obtainable power levels appear to be insufficient for maser pumping. Other solid-state techniques are being evaluated. Author

**N65-16131#** Sperry Gyroscope Co., Great Neck, N.Y. Electro-Optics Group

**INVESTIGATION OF TECHNIQUES FOR ELECTROMAGNETIC ANGULAR ROTATION SENSING** Interim Engineering Report No. 1, 1 Jul.-30 Sep. 1964

Wright-Patterson AFB, Ohio, Res. and Technol. Div., Oct. 1964 55 p refs (Contract AF 33(615)-1931) (AB-1272-0028-1; AD-608276) OTS: \$3.00

A ring laser angular rotation sensor was designed for 100g centrifuge operation. Mode stabilization and control studies are aimed at improving the rotational sensitivity of the ring. Information on mode stability and number of simultaneously oscillating modes is investigated through the use of an analyzing Fabry-Perot cavity. Work on mode pulling and locking, including computer results, is included. The primary emphasis of the program is on designing, evaluating, and delivery ring laser systems for the Holloman 100g, 260-inch centrifuge. Considerations include thermal and mechanical stability. Author

**N65-16252\*#** Wheeler Labs., Inc., Great Neck, N.Y. **DEVELOPMENT OF MACROSCOPIC WAVEGUIDE AND WAVEGUIDE COMPONENTS FOR OPTICAL SYSTEMS** Final Report, Jan. 28-Nov. 28, 1964

E. R. Schineller, D. W. Wilmot, H. M. Heinemann, and H. W. Redlien 28 Nov. 1964 155 p /Its Rept.-1247 (Contract NASw-888) (NASA-CR-60527) OTS: HC \$5.00/MF \$1.00

In the development of single-mode, macroscopic optical waveguides and components, an all-dielectric waveguide, comprising a core and a cladding region of differing dielectric constants, was chosen for detailed study. Theoretical analysis of the waveguide medium resulted in the formulation of mode cutoff conditions, field distributions and propagation characteristics, and various methods for waveguide excitation were

evaluated. Single-mode propagation was obtained from high optical quality fused quartz, ground and polished to size. Component study included theoretical design, performance analysis, and tests of waveguide configurations to determine the feasibility of all-solid components. Conclusions are: (1) Optical detectors fabricated in a single-mode waveguide are sensitive to the transverse distribution of both signal amplitude and phase. (2) Macroscopic optical waveguides and components are feasible. (3) The concept offers promises of high performance components for sophisticated laser systems. M.G.J.

**N65-16320\*** General Dynamics Electronics, Rochester, N.Y. Research Dept.

**LASER MODULATION AT THE ATOMIC LEVEL Monthly Report No. 5, 1-30 Nov. 1964**

E. G. Brock, F. C. Unterleitner, Sr., Y. C. Kiang, and J. F. Stephany 10 Dec. 1964 8 p refs  
(Contract NASw-1003)

(NASA-CR-60572) OTS: HC \$1.00/MF \$0.50

Population inversion as a function of peak magnetic field was measured for a 90° ruby rod. Unlike the 0° rod, minimum inversion coincides with zero magnetic field, and the slope of threshold population inversion versus magnetic field is more than an order of magnitude higher in the high field region for the 90° rod. Rough estimates of the Zeeman splitting to be expected from the lines involved in laser emission at room temperature and at liquid nitrogen temperature have been made. If the crystal field terms in the Zeeman splitting calculation are ignored, each of these lines should split into four components in a magnetic field, the splitting for the room temperature line being approximately four times that of the low temperature line. The primary purpose of these calculations is to give an order of magnitude estimate of the frequency shifts to be anticipated in the pulsed homogeneous field experiments with YAG:Nd<sup>3+</sup> laser.

Author

**N65-16442#** Deutsche Versuchsanstalt für Luft- und Raumfahrt, Porz (West Germany). Institut für Energiewandlung und Elektrische Antriebe

**NONTHERMIC PLASMA AND ELECTRIC CONDUCTIVITY [NICHTTHERMISCHES PLASMA UND ELEKTRISCHE LEITFÄHIGKEIT]**

P. Wahle Aug. 1964 54 p refs In GERMAN

(DLR-FB-64-13; DVL-304) Available from ZLDI, Munich: 13 DM

Intensive tests were performed on plasmas and their behavior in electric and magnetic fields. These tests aim at the technical realization of transforming kinetic energy directly into electric energy, and vice versa, with an acceptable degree of efficiency. In the first case, this transformation takes place in magnetohydrodynamic generators; in the second case, in plasma accelerators. High conductivity on the plasma is essential for a good efficiency. In thermal plasma, this requirement coincides with a high plasma temperature which of course constitutes a high load on the materials. To avoid this thermal stress, the high conductivity of nonthermal plasmas with high electron temperature but low gas temperatures is utilized. This report gives a summary on nonthermal plasma; and the plasma conductivity in electric and magnetic fields is investigated.

Author

**N65-16471#** Pennsylvania Univ., Philadelphia. Johnson Research Foundation

**TEMPERATURE JUMP STUDIES IN THE NANOSECOND RANGE Final Report**

George Czerlinski [1964] 13 p refs

(Contract Nonr-551(46))

(AD-451466)

Temperature jumps within nanoseconds were produced by absorption of some of the light from a Q-switched ruby laser. Such temperature jumps were applied to nonbiological (but chemically connected to biological) systems—bromthymoleblue as a pH indicator, and methyleneblue as an electron-transfer indicator. Although methyleneblue was not originally intended to be used for the purposes of detection, it behaved abnormally at high light-power densities, and further investigation was made of this compound. Two papers describing the results of the work are presented: *Nanosecond Heating of Aqueous Systems by Giant Laser Pulses*, and *Reduced Absorption of Light at High Laser Power Densities*. Also described are investigations of neodymium-doped crystals, feasibility tests of temperature jump cells with heating by giant laser pulses, and studies of rapid detection of laser temperature jumps.

D.S.G.

**N65-16566#** Aerospace Corp., El Segundo, Calif. Electronics Research Lab.

**MODULATION OF THE REFLECTIVITY OF SEMICONDUCTORS**

M. Birnbaum 4 Dec. 1964 13 p refs

(Contract AF 04(695)-469)

(SSD-TDR-64-253; TDR-469(9230-02)-1; AD-455989)

Large increases in the reflectivity of GaAs, Ge, Si, and InSb were observed in the reflection of intense beams of ruby laser light from polished surfaces of these semiconductors. The reflectivity of focused beams incident at the pseudo-Brewster angle is measured as a function of the incident light intensity. Absorption of the laser light in the surface layer produces an electron-hole plasma (density approximately  $10^{21}$  cm<sup>-3</sup> at the highest power levels) that imparts metallic type reflectivity to the semiconductor. At the highest power levels all of the semiconductors were damaged, although in the case of Si the damage was very slight. These large increases in reflectivity indicate a number of applications in the modulation and control of lasers.

Author

**N65-16624** Colorado Univ., Denver

**DEVELOPMENTAL DISTURBANCES OF VERTEBRATE EMBRYOS INDUCED BY LASER RADIATION**

Joseph C. Daniel, Jr., Kenneth R. Lang, and Frank S. Barnes In AF Acad. Proc. of the 1st Ann. Rocky Mt. Bioeng. Symp. [1964] p 240-250 refs (See N65-16601 07-04)

Vertebrate eggs of several different kinds were subjected to laser beams to study the effect of monochromatic, coherent light on embryological development. The results show (1) Deformities can be the product of either the ruby or gas laser. (2) The higher intensities produce more deformities. (3) The effect of laser radiation varies with the growth stage or physiological state of the egg exposed. (4) Pigmentation increases the susceptibility of the subject. (5) Other variables may alter the influence of the laser beam. The quantum energy of laser radiations is too low to cause ionization, excitation or direct bond dissociation but conversion to heat energy is believed to generate free radicals and denature proteins. Unpigmented tissues have low absorption coefficients but the high energy density of incident radiation can cause localized destruction. Pigmented tissue is affected by much lower energy densities.

Author

**N65-16777** Sylvania Electric Products, Inc., Mountain View, Calif. Electronic Defense Labs.

**LIGHT MODULATION DETECTOR Interim Engineering Report No. 2, 15 Jul.-15 Oct. 1964**

Russell Targ, D. E. Caddes, E. O. Ammann, W. D. Bush, and G. A. Massey 16 Nov. 1964 60 p refs

(Contract AF 33(615)-1938)

(EDL-M779; AD-608728) OTS: \$3.00

Work done on an experimental and theoretical program for the stabilization of a laser local oscillator was divided into three main activities: (1) the assembly and test of the electronic and microwave systems which make up the automatic frequency control loop; (2) the evaluation of the single-sideband suppressed-carrier modulator; and (3) the development of a technique for laser mode control in which the He-Ne laser is operated in a manner which forces the laser's modes to comprise the sidebands of an FM signal. The development of this FM laser makes possible the use of high-power multimode lasers in many applications previously limited to the use of single-mode lasers with their necessarily lower power. Also reported is work on techniques which allow certain electro-optic devices, such as shutters and modulators, to be used with light of arbitrary polarization. A related technique permitting heterodyne detection of light with arbitrary polarization of the laser transmitter and local oscillator is also described. Author

**N65-16811\*** Killman Instrument Corp., Elmhurst, N. Y.  
**STUDY OF LASER POINTING PROBLEMS** Bimonthly Technical Report, 1 Oct.-30 Nov. 1964  
 Aaron Wallace 15 Dec. 1964 108 p refs  
 (Contract NASw-929)  
 (NASA-CR-60699; KIC-RD-000162-2) OTS: HC \$4.00/MF \$0.75

The presence of the earth's atmosphere in the communication link with its random turbulence phenomena profoundly affects the system design. It also introduces additional requirements for system synthesis beyond those associated with the extraordinary optical precision due to the narrow beamwidths and the dynamics of closed loop operation with transit time effects and target-observer motions. Attention was concentrated on the "in vacuo" case space vehicle and earth station system configurations, closed loop system analysis, the dynamics of vehicle trajectories and lead angle computations for observer and target motion compensation and the preliminary aspects of laser beam spreading due to atmospheric differential refraction. The report also includes manpower utilization data, and a bibliography of cited references for the main text, mathematical appendixes, and for the appendixes. Author

**N65-16819#** Ohio State Univ. Research Foundation, Columbus. Antenna Lab.  
**SOME CHARACTERISTICS OF Q-SWITCHED LASERS**  
 P. D. Mc Wane (M.S. Thesis—Ohio State Univ.) 30 Nov. 1964 84 p refs  
 (Contract AF 33(657)-10824)  
 (Rept.-1579-18; AD-455880)

Measurements are reported of the variation in power and energy output, beam divergence, and beam intensity from a Kerr cell, Q-switched laser as a function of the parameters of the laser system. Existing theory on power and energy output is reviewed, and an equation for the output is developed which was programed on the computer in an attempt to explain the experimental results. A detailed description of the physical arrangement and the operation of the system is presented. Author

**N65-16822#** Naval Ordnance Test Station, China Lake, Calif. Test Dept.  
**DESCRIPTION OF A NOVEL DESIGN IDEA FOR LASER RANGEFINDERS**  
 T. G. Bergman May 1964 10 p refs  
 (NOTS-TP-3539; AD-443949)

A novel laser-rangefinder design idea that can be used in part or in whole (each part having distinct advantages or characteristics) is presented. Advantages include: (1) only one

objective lens for projecting or recollimating laser light and for the collection of the return beam, (2) automatic gain control over return intensity, and (3) no oscillator nor fast time response electronic circuitry. Since spherical aberration and lens configuration are important in this design concept, they are examined in some detail. Author

**N65-16944#** Lincoln Lab., Mass. Inst. of Tech., Lexington.  
**SOLID STATE Division 8 Quarterly Progress Report, 1 Jul.-30 Sep. 1964**  
 Alan L. Mc Whorter et al 18 Nov. 1964 17 p refs  
 (Contract AF 19(628)-500)  
 (ESD-TDR-64-560; AD-608569)

Research is reported in the fields of solid-state devices, lasers, materials, band structure and spectroscopy of solids, and magnetism and resonance. Laser action, in which coherent radiation at 5.2 microns emanates from the bulk of the semiconductor, was obtained from InSb diodes in which an electron-hole plasma was established. Laser action was obtained in GaAs at liquid helium temperature by generating electron-hole pairs with a beam of 50-keV electrons. Stimulated Raman emission at 90° to the ruby-laser beam in CS<sub>2</sub> was obtained, and the threshold was compared with that in nitrobenzene. An electric furnace was developed for heating samples to 2400° C in oxidizing atmospheres, as well as in neutral or reducing atmospheres. D. E. W.

**N65-17148#** Sperry Gyroscope Co., Great Neck, N. Y.  
**COHERENT OPTICAL ARRAY TECHNIQUES** Interim Technical Documentary Report, 1 Jun.-31 Aug. 1964  
 Griffiss AFB, N. Y., RADC, Jan. 1965 60 p refs  
 (Contract AF 30(602)-3329)  
 (AB-1272-0016-2; RADC-TDR-64-462; AD-610466)

In an overall plan to demonstrate feasibility by developing a subassembly consisting of a cw laser master oscillator driving two pulsed laser power amplifiers in parallel, an investigation was conducted for an operating wavelength of 1.06 microns. Solid-state and gas lasers were considered for the master oscillator. As no satisfactory 1.06-micron transition was found for a gas laser system, effort is being concentrated on solid-state devices. A Nd:CaWO<sub>4</sub> laser has produced a multimode cw output of 160 milliwatts. Single-mode work is being pursued. Solid-state Nd:CaWO<sub>4</sub> crystals were grown, cut, polished, and coated for amplifier functions at 1.06 microns. Gain of several dB was measured. Mach-Zender and modified Michelson interferometers were constructed for phase shift and array studies. A KDP electro-optical phase shifter was designed, constructed, and incorporated in the Mach-Zender device. Author

**N65-17210#** Illinois Univ., Urbana. Gaseous Electronics Lab.  
**THEORY OF THE LASER INTERFEROMETER AND ITS USE IN PLASMA DIAGNOSTICS**  
 J. B. Gerardo, J. T. Verdeyen, and M. A. Gusinow 1 Dec. 1964 99 p refs *Its Sci. Rept. No. 1*  
 (GRANT DA-ARO(D)-31-124-G582)  
 (AROD-4832-2; AD-610321)

The theory of the laser interferometer and its application in investigations of relatively dense to very dense gaseous plasmas are discussed. It is shown that the sensitivity of the interferometer can be greatly improved by utilizing a spherical geometry reference cavity rather than one formed by planar mirrors. The parameters that determine the sensitivity of a spherical geometry laser interferometer are described and detailed theory of such is given. Particular emphasis is placed on determining the maximum frequency response of the interferometer. The parameters that limit the frequency response are given and it is shown that by proper selection of these

parameters and proper detection techniques, it is possible to detect resonances at rates in excess of 50 per  $\mu\text{sec}$ . Author

**N65-17373#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering

# **LASER VELOCIMETRY**

Phillip Charles Staas, Jr. (M.S. Thesis) Aug. 1964 62 p refs (GE/EE/64-18; AD-608087)

Laser velocimetry is the measurement of transverse velocity by detection of motion in reflected laser radiation. Reflections from a diffuse surface form a diffraction field which moves in space as the surface moves. A photomultiplier and optical grating detect the diffraction field motion as a frequency spectrum. The center frequency of the detector output is equal to the velocity of the diffraction field divided by two times the width of one grating line. The diffraction field velocity is a linear function of reflecting surface velocity and detector range, and a nonlinear function of incident laser radiation wave fronts.

Author

**N65-17442#** Korad Corp., Santa Monica, Calif.

# **GaAs LASER DIODES Quarterly Progress Report, 1 Jul.-30 Sep. 1964**

R. A. Sehr and W. J. Rundle [1964] 27 p refs

(Contract DA-28-043-AMC-00235(E))

(QPR-1; AD-456022)

Device development and laser diode fabrication are described. Experimental work, aimed at improved laser performance, concentrated on diffusion experiments and methods of increasing electrical and thermal contact resistance. Procedures were established for guaranteeing a junction flatness of  $\pm 0.05\mu$ , and a bonding technique was developed which enables electrical contact resistivities of less than  $5 \times 10^{-5}$  ohm  $\text{cm}^2$ . A new laser geometry was tested, and a fabrication technique was developed. Twenty laser diodes were mounted on a coaxial copper heat sink. The fabrication and test methods utilized are outlined.

Author

**N65-17595#** North Carolina State Coll., Raleigh. School of Physical Sciences and Applied Mathematics

# **NUCLEAR ENERGY DRIVEN LASER SYSTEMS Final Report**

A. C. Menius, Jr. Jun. 1964 52 p refs

(Contract DA-01-009-AMC-39(Z))

(AD-455571)

## **CONTENTS:**

1. PART A: THE EFFECTS OF GAMMA IRRADIATION ON THE ENERGY OUTPUT OF RUBY LASER CRYSTALS  
W. R. Davis, M. K. Moss, and C. R. Philbrick p 1-38 refs (See N65-17596 08-26)

2. PART B: GROWTH, CHARACTERIZATION, AND FINISHING OF LASER CRYSTALS H. Palmour and R. D. McBrayer p 39-45 refs (See N65-17597 08-26)

**N65-17596** North Carolina State Coll., Raleigh. School of Physical Sciences and Applied Mathematics

# **THE EFFECTS OF GAMMA IRRADIATION ON THE ENERGY OUTPUT OF RUBY LASER CRYSTALS**

William R. Davis, Marvin K. Moss, and Charles R. Philbrick *In its Nucl. Energy Driven Laser Systems* Jun. 1964 p 1-38 refs (See N65-17595 08-26)

The energy output of ruby laser crystals was significantly increased by prior irradiation with cobalt-60 gamma dosages of 0, 700, 1000, 1400, and 1700 roentgens. Calorimeter

relative energy outputs of 1.0, 1.7, 2.0, 2.2, and 2.8 were obtained. Increased outputs as large as a factor of 5 were achieved, and increases as large as 10 should soon be available. E.E.B.

**N65-17597** North Carolina State Coll., Raleigh. School of Physical Sciences and Applied Mathematics

# **GROWTH, CHARACTERIZATION, AND FINISHING OF LASER CRYSTALS**

Hayne Palmour and R. Douglas Mc Brayer *In its Nucl. Energy Driven Laser Systems* Jun. 1964 p 39-45 refs (See N65-17595 08-26)

Capabilities for growing crystals of ruby by the traditional Verneuil flame-fusion technique are reported. The likelihood of successful adaptation of the Chochalski pulling method to ruby, using tungsten crucibles in vacuo or argon, or iridium crucibles in argon or oxidizing environments is considered. E.E.B.

**N65-17872\*#** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

# **METEOROID SIMULATION USING LASERS**

O. K. Hudson 25 Aug. 1964 15 p refs

(NASA-TM-X-53122) OTS: HC \$1.00/MF \$0.50

This is a brief discussion of the current state of laser technology relative to meteoroid simulation. It shows that efforts up to this time are inadequate, but that a carefully designed experiment with the above objective in view, and employing essentially off-the-shelf apparatus, may enable one to find the laws of similarity and of correlation between both kinds of high-energy impact phenomena. Some recent literature is surveyed and references are provided.

Author

**N65-17927#** American Optical Co., Southbridge, Mass. Research Div.

# **STUDY AND EXPERIMENTATION TO OBTAIN SUN-PUMPED LASER COMMUNICATIONS TRANSMITTER Interim Engineering Report**

C. G. Young and E. O. Dixon Jan. 1965 54 p refs

(Contract AF 33(615)-1899)

(AD-610601)

Preliminary experiments culminating in approximately a watt of laser output from a glass laser fiber at room temperature, when pumped by the solar simulator, are described. Efforts to improve neodymium-doped glass and calcium tungstate are reported. A discussion of these laser materials and also neodymium-doped yttrium aluminum garnet is included. Special pumping configurations designed to exploit the properties of the available laser materials, which have been designed and in some cases fabricated, are described. These include side-pumped crystalline lasers by cylindrical refractors or reflectors, with diameters in these fragile materials which are not impractically small. New end-pumping schemes employing liquid immersion also are described. Some additional thermal considerations apropos yttrium aluminum garnet and liquid-immersed long glass fibers are presented. A section is included that describes the work on neodymium-doped  $\text{CaWO}_4$  and YAG crystal synthesis.

Author

**N65-17931#** Centro di Studio per la Fisica delle Microonde, Florence (Italy).

# **THEORETICAL STUDY OF OPTICAL CAVITIES Final Technical Report**

L. Ronchi, A. M. Scheggi, and G. Toraldo di Francia. Jun. 1964 22 p refs  
(Contract AF 61(052)-536)  
(AFCL-64-1015; AD-610862)

A theoretical study was performed of the resonant modes of a laser cavity having end mirrors with periodic reflectivity. Two examples were examined: (1) end mirrors constituted by two identical strip diffraction gratings; and (2) end mirrors constituted by definite-ruling phase gratings. In the first example, the modes and the corresponding eigenvalues were evaluated in successive approximations. It was found that a particular frequency exists for which losses are very low, while neighboring frequencies suffer heavy losses. This effect increases very rapidly with the total number of strips in the grating. In the case of phase gratings at transverse resonance, the problem can be reduced to that of a resonator terminated by strip gratings. However, the study was not completed.

Author

**N65-17940#** Hughes Aircraft Co., Fullerton, Calif. Ground Systems Group  
**LASER COMMUNICATIONS STUDY Quarterly Progress Report, 1 Jul.-30 Sep. 1964**

T. M. Straus, J. E. Kiefer, and W. K. Pratt 18 Dec. 1964 47 p refs

(Contract DA-28-043-AMC-00195(E))  
(FR-64-19-301; AD-610602)

The purpose is to develop a coherent optical communications system capable of being utilized as a tool in the gathering of information relating to the effects of atmospheric anomalies on a frequency modulated laser beam. The program was divided into three phases: a 3-month study phase in which the laser communication system is defined, a 6-month developmental phase during which the system is fabricated, and a 3-month test phase in which the system and the effects of the atmosphere are evaluated. This report describes a frequency modulation study. One project is valuable because of the practical experience it provides with laser heterodyne systems.

Author

**N65-18264\*#** National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.  
**GEOS-1 LASER RETROREFLECTOR DESIGN AND PRELIMINARY SIGNAL CALCULATIONS**

H. H. Plotkin Jul. 1964 20 p  
(NASA-TM-X-55129; X-524-64-205) OIS: HC \$1.00/MF \$0.50

The gravity-gradient-stabilized satellite GEOS 1 is considered, with special attention being given to the array of cube-corner prisms along its bottom surface. This array forms a retro-reflecting surface for laser beams directed from the ground and is especially effective in directions close to the normal of the surface. The advisability of tilting the symmetry axes of the cube-corners at various angles to the plane normal, in order to equalize the effective reflecting area presented to rays incident over a large range of angles, is examined. Preliminary signal calculations are also performed that can be useful for the design of ground stations.

D.E.W.

**N65-18440#** United Aircraft Corp., East Hartford, Conn. United Aircraft Research Labs.  
**ULTRASONIC LASER MODULATION TECHNIQUES First Quarterly Progress Report, 1 Jul.-30 Sep. 1964**

A. J. De Maria, D. E. Finchbaugh, and G. E. Danielson, Jr. 11 Jan. 1965 51 p refs  
(Contract DA-28-043-AMC-00259(E))  
(C-920259-3; AD-454484)

The equivalence of the phase modulation index of a light beam and the Raman-Nath parameter of an acoustic diffraction grating is developed. The diffraction integral for an amplitude modulated acoustic wave is solved. The solution reverts

to the Raman-Nath result when the amplitude modulation index goes to zero. A fused quartz, 54-Mc/sec acoustic diffraction modulator was constructed and yielded approximately 100% modulation with an input power of approximately 40 W. The acoustic waves generated a maximum change in the refractive index of approximately  $5 \times 10^{-6}$  in the fused quartz block. The modulator was used to modulate the losses of the feedback cavity of a  $\text{Nd}^{3+}$  glass laser at a frequency commensurate to some multiple of the axial mode spacing. A He-Ne laser beam was used to examine the index of refraction gradients produced in a liquid by a barium titanate ceramic transducer (formed into an arc of a short section of right circular cylinder) radiating into a tetrachlorethylene-filled cell at 400 kc/sec.

Author

**N65-18624#** Westinghouse Electric Corp., Baltimore, Md. Surface Div.

**INVESTIGATION OF GAS IONIZATION PHENOMENON AT OPTICAL AND IR FREQUENCIES First Technical Documentary Report, 11 Feb.-11 Aug. 1964**

L. C. Van Allen, A. V. Phelps, and R. W. Waynant Griffiss AFB, N. Y., RADC, Jan. 1965 58 p refs

(Contract AF 30(602)-3332)  
(RADC-TDR-64-422; AD-610590)

Results of the first half of the program are summarized and the status at that point is given. The experimental laser system is described and the calibration and monitoring procedures are discussed. Breakdown time statistics and charge measurements obtained during this time are presented. The theoretical study results obtained to date in the areas of the nonlinear ionization initiation mechanisms and the extension of the microwave breakdown theory are discussed. A preliminary description of the breakdown process is given.

Author

**N65-18629#** Philco Corp., Blue Bell, Pa. Philco Research Labs.

**COHERENT OPTICAL PARAMETRIC TECHNIQUES Second Quarterly Report**

C. Wang Griffiss AFB, N. Y., RADC, Dec. 1964 15 p  
(Contract AF 30(602)-3364)

(RADC-TDR-64-484; AD-610624)

Angular dependence of incident radiation of ruby light to produce its second harmonic in ADP was measured. The expected angle of incidence for parametric amplification of 6328 Å light by this second harmonic was calculated, and a preliminary setup for this amplification was constructed.

Author

**N65-18884#** Library of Congress, Washington, D. C. Aerospace Technology Div.

**FOREIGN SCIENCE BULLETIN, VOLUME 1, NUMBER 2 Feb. 1965 74 p refs Sponsored by DOD**  
(AD-455792)

#### CONTENTS:

1. MULTICAVITY RADIOMETER MASERS FOR STUDIES OF THE 21-cm HYDROGEN LINE S. G. Hibben p 1-6 refs (See N65-18885 09-16)

2. BIOLOGICAL AND MEDICAL ASPECTS OF MICROWAVES C. Dodge p 7-19 refs (See N65-18886 09-04)

3. SOVIET RESEARCH ON MICROWAVE POWER GENERATION. II. OPTIMIZATION OF THE PERFORMANCE OF PLANOTRONS AND NIGOTRONS A. Iwanovsky p 20-28 refs (See N65-18887 09-10)

4. THE DEPENDENCE OF OPTIMAL CONTROL ON THE PARAMETERS OF THE CONTROLLED PROCESS L. Kacinskas p 29-32 refs (See N65-18888 09-10)



5. THE INFLUENCE OF MICROWAVES ON THE FUNCTIONAL CONDITION OF THE NERVE C. Dodge p 33-38 ref (See N65-18889 09-04)

6. GAS-PHASE RADIATION-INDUCED GRAFT POLYMERIZATION: A PREPARATIVE METHOD FOR COHERENT SEMICONDUCTING POLYMER BASED MATERIALS S. Markov p 39-43 refs (See N65-18890 09-26)

7. SCIENCE & TECHNOLOGY NOTES p 44-57 refs

8. CONFERENCES p 58-68 refs

**N65-18885** Library of Congress, Washington, D. C. Aerospace Technology Div.

**MULTICAVITY RADIOMETER MASERS FOR STUDIES OF THE 21-cm HYDROGEN LINE**

S. G. Hibben *In its Foreign Sci. Bull.* Feb. 1965 p 1-6 refs (See N65-18884 09-34)

A discussion is presented of the design and operation of two types of dual-cavity masers intended for recording 21-cm emission from galactic hydrogen. Results are described for a passive-active type and for a variant in which both cavities contain active ruby. The advantages in gain-bandwidth product and stability over the single-cavity maser are pointed out. The general case of a multicavity maser using active EPR material throughout is analyzed theoretically, and varying degrees of nonreciprocal coupling are examined. Author

**N65-19166#** Army Electronics Labs., Fort Monmouth, N. J. Solid State and Frequency Control Div.

**EXPERIMENTS RELATING TO REGENERATIVE LASER AMPLIFIER DESIGN**

H. Jacobs, J. Castro, F. A. Brand, C. Lo Cascio, and G. Novick (Monmouth Coll.) Dec. 1964 38 p refs (ECOM-2531; AD-610111)

Experiments and calculations are reported in efforts to determine the applicability of multiple reflection concepts to laser amplifier design. The data indicate at least qualitative agreement with proposed theories in that if the regenerative amplifier is pumped with too much energy the amplification will decrease. Estimates of the population inversion of the amplifier show that as the pump light from the xenon source irradiates the ruby crystal,  $\alpha$  increases in the amplifier before amplifier oscillations appear, during the period of oscillations, and even after the amplifier oscillations cease. However, as the time between the quenching of the oscillation of the amplifier and the arrival of the input signal increases, the gain decreases. This effect is consistent with the multiple reflection theory. Author

**N65-19297#** RAND Corp., Santa Monica, Calif.

**IS LASER RADIATION CLASSICAL?**

Dennis Holliday and A. E. Glassgold Jan. 1965 9 p refs (Contract AF 49(638)-700; Proj. RAND) (RM-4435-PR; AD-610953)

An attempt is made to solve the quantum mechanical equations of motion for an ideal laser, by using the concept of classical motion in quantum mechanics precisely. It is shown that the laser produces a classical field while undergoing linear self-amplification. The nonlinear behavior which follows the linear amplification then leads to amplitude stabilization of this classical field; the phase of the field will be uniformly distributed. Author

**N65-19317#** Lincoln Lab., Mass. Inst. of Tech., Lexington. **SOLID STATE RESEARCH, 1 JULY 1964-30 SEPTEMBER 1964**

A. L. McWhorter et al 17 Dec. 1964 74 p refs (Contract AF 19(628)-500) (ESD-TDR-64-561; AD-609828)

The topics covered are *Solid State Device Research, Laser Research, Materials Research, Band Structure and Spectroscopy of Solids, and Magnetism and Resonance.* Author

**N65-19354#** Perkin-Elmer Corp., Norwalk, Conn. Electro-Optical Div.

**RESEARCH AND DEVELOPMENT OF NEW LASER MATERIALS Final Report, 1 May-30 Sep. 1964**

Robert C. Linares 30 Oct. 1964 54 p refs (Contracts AF 19(628)-4057; AF 19(628)-2965) (M7881; AFCRL-64-971; AD-611177)

Crystals of  $\text{Al}_2\text{O}_3:\text{Mn}^{4+}$ ,  $\text{Al}_2\text{O}_3:\text{Cr}^{3+}$ ,  $\text{Al}_2\text{O}_3:\text{V}^{2+}$ ,  $\text{MgO}:\text{Cr}^{3+}$ ,  $\text{Ga}_2\text{O}_3:\text{Cr}^{3+}$ ,  $\text{Al}_4\text{SiO}_8:\text{Cr}^{3+}$ ,  $\text{MgAl}_2\text{O}_4:\text{Cr}^{3+}$ ,  $\text{MgAl}_2\text{O}_4:\text{V}^{2+}$ ,  $\text{BeAl}_2\text{O}_4:\text{Cr}^{3+}$  and  $\text{Gd}_3\text{Ga}_5\text{O}_{12}:\text{Cr}^{3+}$  were grown for laser and spectral evaluation. The physical and optical measurements were made on the crystals, which were grown utilizing the flame fusion, Czochralski, flux, and vapor techniques. Recommendations are made regarding the potential for future study of each material. Author

**N65-19528#** Columbia Univ., New York. Columbia Radiation Lab.

**THE OPTICAL MASER APPLIED TO BRILLOUIN SCATTERING SPECTROSCOPY Final Report, Oct. 1, 1962-Dec. 31, 1964**

R. Novick Jan. 1965 15 p refs (Grant DA-ARO(D)-31-124-G380) (AROD-3922-13; AD-458654)

The successful observation of the spectral profile of the central Brillouin component is reported. The line shape was found to be quite closely fitted by a Lorentzian curve as predicted earlier. The temperature and angular dependence of the Lorentzian line were also successfully observed. Specific technical developments reported include the construction of a laser homodyne spectrometer, which comprises a laser light source, a divided optical path, the externally driven Bragg tanks, and the detection apparatus and associated data processing equipment, and the design and construction of a temperature control system capable of maintaining the scattering sample at a fixed known temperature to within  $\pm 0.001^\circ \text{C}$ . Three significant achievements are reported: the first observation of time-dependent concentration fluctuations in a binary mixture, the measurement of the size of minute colloidal particles with diameters less than 1000 Å, and the measurement of liquid flow rates to values as small as 0.004 cm/sec. D.E.W.

**N65-19752\*#** Case Inst. of Tech., Cleveland, Ohio.

**SURVEY OF KNOWN LASER TRANSITIONS**

H. J. Cook, W. B. Johnson, and Marcia L. Parsons Sep. 1964 95 p refs (Grant NSG-198)

(NASA-CR-57334; A-32) CFSTI: HC \$3.00/MF \$0.75

A list is presented of approximately 700 spectral lines of observed laser transitions, of which the vast majority were observed in gas lasers. Elements and molecules used to produce laser action in the gas phase include argon, bromine, carbon, chlorine, cesium, CN, CO,  $\text{CO}_2$ , helium, mercury, HCN, iodine, krypton, nitrogen, neon, oxygen, OD, OH, sulfur, and xenon. Elements whose ions have been used to produce laser action in a host material include chromium, dysprosium, europium, gadolinium, holmium, neodymium, nickel, praseodymium, samarium, thulium, uranium, and ytterbium. Wavelengths produced by gas lasers range from 0.2678  $\mu$  to 337  $\mu$ , and those produced by solid lasers range from 0.3125  $\mu$  to 2.7  $\mu$ . D.E.W.

**N65-19791#** Case Inst. of Tech., Cleveland, Ohio. **LASERS AND LASER SPECTROSCOPY**

W. B. Johnson [1964] 215 p refs Presented at the 3d Natl. Meeting of the Soc. for Appl. Spectry, 28 Sep.-2 Oct. 1964 (TR-A-34)

A general discussion of lasers and their applications to various spectroscopic problems is presented. Laser technology applicable to these problems is discussed, and methods are covered for modulating and demodulating light, for producing various laser transitions, for initiating the stimulated Raman effect, and for observing nonlinear optical phenomena. Detectors suitable for use in such experiments are considered, as are techniques for providing vernier frequency shifts. The application of these subjects to specific problems is discussed.

Author

**N65-19816#** Lincoln Lab., Mass. Inst. of Tech., Lexington.  
**SOLID STATE Quarterly Progress Report, 1 Apr.-30 Jun. 1964**

Alan L. McWhorter and Peter E. Tannenwald 31 Jul. 1964 18 p ref

(Contract AF 19(628)-500)

(ESD-TDR-64-349; AD-603514) CFSTI: \$1.00

Progress is reported in the research fields of solid state, lasers, materials, band structure and spectroscopy of solids, and magnetism and resonance.

E. E. B.

**N65-19863\*#** General Dynamics/Electronics, Rochester, N. Y. Research Dept.

**LASER MODULATION AT THE ATOMIC LEVEL Monthly Report No. 6, Dec. 1964**

E. G. Brock, F. C. Unterleitner, Y. C. Kiang, and J. F. Stephany 10 Jan. 1965 13 p refs

(Contract NASw-1008)

(NASA-CR-57464) CFSTI: HC \$1.00/MF \$0.50

The frequency shift of ruby laser emission under inhomogeneous magnetic fields was measured by time resolved spectroscopy. The  $0^\circ$  ruby shows a frequency shift of  $0.32 \text{ cm}^{-1}$  with 5 kG peak field, while  $90^\circ$  ruby emission shifts  $+0.25 \text{ cm}^{-1}$  for the same field strength. The influence of crystal field splitting on the  $\text{YAG:Nd}^{3+}$  laser transition Zeeman splitting is discussed. The possibility of confirming nearby tetragonal site symmetry is also discussed.

Author

**N65-19952#** General Telephone and Electronics Labs., Inc., Bayside, N. Y.

**OPTICAL PROPERTIES OF BINARY GAS PLASMAS Technical Report, 15 Nov. 1963-14 Sep. 1964**

W. R. Watson and V. J. Fowler Wright-Patterson AFB, Ohio, AFSC, 30 Nov. 1964 26 p

(Contract AF 33(615)-1050)

(TR-64-257.10; AFAL-TR-64-289; AD-609125)

This report describes a project (1) to determine changes that occur in the composition of the gas during operation of a discharge tube such as is used in helium-neon lasers, and (2) to develop suitable instrumentation for such investigations. The omegatron mass spectrometer system developed is described, and data obtained with it on a helium-neon laser are reported. The laser output power and intensities of some lines of the emission spectrum of the discharge are also reported as functions of time of continuous operation of the laser.

Author

**N65-20002#** Raytheon Co., Waltham, Mass. Research Div.  
**GASEOUS LASER RESEARCH Interim Engineering Report No. 3, 1 Nov. 1964-31 Jan. 1965**

F. Horrigan, S. Koozekanani, R. Paananen, and D. Warshawer [1965] 48 p refs

(Contract AF 33(615)-1949)

(S-740; AD-611831)

Emphasis was placed on spontaneous emission studies of level population dependences on gas pressure, discharge current, and tube diameter, and the laser power output was studied as a function of these parameters. Measurements of metastable densities via absorption studies were made, and the parameter change effects in the computer model of a discharge excited laser system were investigated. Results are presented and conclusions are drawn concerning the excitation mechanisms responsible for the laser action in pure xenon discharge excited laser systems.

Author

**N65-20038#** Stanford Univ., Calif. Microwave Lab.  
**MICROWAVE RESEARCH Quarterly Status Report No. 23, 1 Aug.-31 Oct. 1964**

M. Chodorow Dec. 1964 18 p refs

(Contract Nonr-225(48))

(ML-1277; AD-610667)

Eight projects in microwave research are described: (1) acoustic wave amplification—microwave region in piezoelectric semiconductors; (2) optical masers—extension and improvement of their performance for physical research problems; (3) diffraction of light waves by hypersound—search for crystals with stronger diffracting power; (4) transient effects in optical masers—control of buildup of laser oscillations; (5) electron-phonon interactions—electron scattering by acoustic phonons and relaxation time in n-type InSb, and design of a cryostat for ultrasonic attenuation in solids; (6) interaction of spin waves and electrons—parametric excitation of growing spin waves; (7) geometrical optics of acoustic waves—possibilities of an ultrasonic microscope, and focussing of acoustic waves in piezoelectric crystals; and (8) Raman scattering from birefringent crystals—development of a continuously tunable optical source utilizing Raman scattering from a birefringent crystal.

R. W. H.

**N65-20072#** Kollsman Instrument Corp., Elmhurst, N. Y.  
**LASER OPTICAL ALIGNMENT SYSTEM**

1 Feb. 1965 10 p

(LOPALS-1)

The design specifications are presented for an optical theodolite employing a laser system as the self-contained pulsed light source, and using photomultiplier tubes in the optical nulling feedback loops to automatically obtain the desired information. The theodolite axes are aligned in the standard manner, and the detection technique is particularly reliable with regard to fog and heat shimmer. After setup the instrument operates automatically, continuously accumulating data on target motion. The all-weather design range is at least 1000 ft.

E. P. V.

**N65-20134#** Joint Publications Research Service, Washington, D. C.

**TRANSLATIONS ON COMMUNIST CHINA'S SCIENCE AND TECHNOLOGY, NO. 161**

19 Mar. 1965 143 p refs Transl. into ENGLISH of selected articles from Chinese Publ.

(JPRS-29200; TT-65-30547) CFSTI: \$4.00

#### CONTENTS:

1. CHINA'S ACHIEVEMENTS IN INTERNAL MEDICINE DURING THE PAST FIVE YEARS p 1-30 refs
2. PHYSICS OF METALS p 31 ref
3. THE RECENT RESEARCH AND CONTROL ON TRACHOMA VIRUS IN CHINA p 32-53 refs
4. THE TROPICAL RELATIVES OF THE CHINESE FLORA Cheng-i Wu p 54-66
5. STIMULATED EMISSION OF LIGHT FROM PURE Ze AND He-Ze C. Lin, C. Hsing, C. Wang, C. Wan, and F. Huang p 67-73 refs (See N65-20135 10-16)

6. THE He-Ne LASER WITH SILVER COATINGS AND DIELECTRIC COATINGS C. Lin, C. Hsing, C. Wang, C. Wan, F. Huang et al p 74-80 refs (See N65-20136 10-16)

7. FM-8 TYPE OF ELECTRONIC ANALOG COMPUTER PRODUCED IN TIENTSIN Wang Huang-sheng p 81

8. ELECTRONIC ANALOG COMPUTERS Ching-ying p 82-87

9. TRANSISTOR CIRCUIT DESIGN (5) H. Ling p 88-95 ref (See N65-20137 10-09)

10. CHEMICAL PROTECTIVE DRUGS AGAINST IONIZING RADIATION C. Hsiao p 96-105 refs (See N65-20138 10-04)

11. THE EFFECTIVE ANTIDOTE FOR ORGANOPHOSPHOROUS DRUG POISONING—"PYRALDOXIMI METHIODIDUM" (PAM) Wan-ling Wu and C. Chang p 107-115 refs

12. IMPROVING THE PRODUCTION OF NAPHAZO-LINE HYDROCHLORIDE EYE (NOSE) DROPS Chi-chang Yang p 116-119 refs

13. PEIPING DOCTORS FORM 12 CIRCUIT TEAMS TO SERVE COUNTRYSIDE p 120-124

14. DISCUSSION FORUM HELD BY MEDICAL PERSONNEL IN SHANGHAI p 125-127

15. CHINA PRODUCES NEW CURE FOR ECTOPIC PREGNANCY p 128-129

16. CORAL REEFS IN SOUTH SEA INVESTIGATED p 130

17. WUHAN INTRODUCES NEW TREATMENT FOR INTERNAL PILES p 131

18. AGRICULTURAL SCIENTIFIC EXPERIMENTS IN RURAL AREAS p 132-133

19. GEOMAGNETIC SURVEYS AT HIGHEST ALTITUDE p 134-135

20. PENG CHIA-MU: AN UNUSUAL SCIENTIST p 136-139

**N65-20135** Joint Publications Research Service, Washington, D. C.

#### STIMULATED EMISSION OF LIGHT FROM PURE Xe AND He-Xe

Chun-Ch'en Lin, Ch'en Hsing, Ching-jui Wang, Chung-i Wan, and Fei-hsuan Huang *In its* Transl. on Communist China's Sci. and Technol., No. 161 19 Mar. 1965 p 67-73 refs Transl. into ENGLISH from K'o Hsueh T'ung Pao (Peking), no. 1, Jan. 1965 p 71-72 (See N65-20134 10-34) CFSTI: \$4.00

Stimulated light emissions from pure Xe and He-Xe gases in quartz discharge tubes showed a generally greater output through high-frequency discharge than through direct-current discharge. A high He-Xe mixture ratio induced cataphoresis and a severe Xe cleaning action. Wavelength measurements by infrared spectrometer were 2.027 microns for the pure Xe laser. Measurements of the He-Xe laser from coupled light stimulation of confocal or plane reflectors were 2.027 $\mu$ ; from coupled window lights of the discharge tube, 3.368 $\mu$ ; and from a window with a 20° angle, 3.508 $\mu$ ; with a relative power ratio of 64:9.4:100, respectively. G.G.

**N65-20136** Joint Publications Research Service, Washington, D. C.

#### THE He-Ne LASER WITH SILVER COATINGS AND DIELECTRIC COATINGS

Chün-Ch'en Lin, Ch'en Hsing, Ching-jui Wang, Chung-i Wan, Fei-Hsuan Huang et al *In its* Transl. on Communist China's Sci. and Technol., No. 161 19 Mar. 1965 p 74-80 refs Transl. into ENGLISH from K'o Hsueh T'ung Pao (Peking), no. 1, Jan. 1965 p 73-74 (See N65-20134 10-34) CFSTI: \$4.00

Laser emissions from a He-Ne mixture in a quartz discharge tube with silver coating produced output wavelengths of 1.1530 and 3.39 microns at high frequency excitation. The output power of the dc discharge was more than twice that of the high frequency discharge. The same gas mixture in a quartz tube with dielectric coating resulted in the 6328 Å light output, and in a hard glass discharge tube with 2 quartz glass planes the 1.1530 output was obtained. It was concluded that the technical requirements for development of relatively high efficiency gas lasers are not too stringent. G.G.

**N65-20166#** Services Electronics Research Lab., Baldock (England).

**S.E.R.L. TECHNICAL JOURNAL, VOL. 15, NO. 1, FEBRUARY 1965**

[1965] 81 p refs

#### CONTENTS:

1. A TRANSVERSE WAVE TRAVELLING WAVE TUBE (T.W.T.W.T.) J. E. Carroll 13 p refs (See N65-20167 10-09)

2. A NEW EQUIVALENT CIRCUIT FOR COUPLED CAVITY STRUCTURES H. J. Curnow 14 p refs (See N65-20168 10-09)

3. YIELD FROM BAKABLE ERBIUM TARGETS FOR NEUTRON GENERATORS L. N. Large and H. Hill 7 p refs (See N65-20169 10-24)

4. A PULSED GAS LASER FOR THE FAR INFRA-RED L. N. Large and H. Hill 7 p refs (See N65-20170 10-16)

5. STIMULATED EMISSION IN THE FAR INFRA-RED FROM WATER VAPOUR AND DEUTERIUM OXIDE DISCHARGES L. E. S. Mathias and A. Crocker 5 p refs (See N65-20171 10-16)

6. LASER OSCILLATIONS FROM NITROUS OXIDE AT WAVELENGTHS AROUND 10.9  $\mu$  L. E. S. Mathias, A. Crocker, and M. S. Wills 4 p refs (See N65-20172 10-16)

7. LASER OSCILLATIONS AT WAVELENGTHS BETWEEN 21 AND 32  $\mu$  FROM A PULSED DISCHARGE THROUGH AMMONIA L. E. S. Mathias, A. Crocker, and M. S. Wills 3 p refs (See N65-20173 10-16)

8. OPTICAL GAIN IN NEON AND HELIUM/NEON PULSED DISCHARGES D. N. Clunie and N. H. Rock 4 p refs (See N65-20174 10-16)

9. A COMPACT PULSE GENERATOR FOR DRIVING GALLIUM ARSENIDE LASERS AT ROOM TEMPERATURE R. F. Broom 7 p refs (See N65-20175 10-16)

10. A SEMICONDUCTOR LASER ARRAY R. F. Broom 4 p (See N65-20176 10-16)

11. DESIGN OF A COMPACT 100-WATT GaAs LASER TRANSMITTER K. G. Hambleton and F. E. Birbeck 9 p refs (See N65-20177 10-16)

**N65-20170** Services Electronics Research Lab., Baldock (England).

#### A PULSED GAS LASER FOR THE FAR INFRA-RED

L. N. Large and H. Hill *In its* S.E.R.L. Tech. J., Vol. 15, No. 1, Feb. 1965 [1965] 7 p refs Submitted for Publication (See N65-20166 10-16)

A compact sealed-off pulsed laser was developed for the far infrared region of the spectrum. This source which is 1 meter in length emits radiation at 27.9 $\mu$  using a pulsed water vapor discharge. Peak output powers around 10 watts are obtained in light pulses of 1-microsecond duration. By using a water vapor replenisher and by constructing the laser so that it is capable of thorough vacuum baking before filling, a long life is insured. This source has immediate applications in the field of plasma diagnostics. Author

**N65-20172** Services Electronics Research Lab., Baldock (England).

#### LASER OSCILLATIONS FROM NITROUS OXIDE- AT WAVELENGTHS AROUND 10.9 $\mu$

L. E. S. Mathias, A. Crocker, and M. S. Wills *In its S.E.R.L. Tech. J.*, Vol. 15, No. 1, Feb. 1965 [1965] 4 p refs Submitted for Publication (See N65-20166 10-16)

Laser oscillations at a number of closely spaced wavelengths around  $10.9\mu$  were obtained from a pulsed electrical discharge through nitrous oxide. The transitions are P branch transitions in a vibration-rotation band, either the 001 to 100 or the 002 to 101 band, in the ground electronic state of the molecule.

Author

**N65-20173** Services Electronics Research Lab., Baldock (England).

**LASER OSCILLATIONS AT WAVELENGTHS BETWEEN 21 AND  $32\mu$  FROM A PULSED DISCHARGE THROUGH AMMONIA**

L. E. S. Mathias, A. Crocker, and M. S. Wills *In its S.E.R.L. Tech. J.*, Vol. 15, No. 1, Feb. 1965 [1965] 3 p refs Submitted for Publication (See N65-20166 10-16)

Laser oscillations were obtained at a pressure of 2.4 torr and charging voltage of 27 kV with ammonia flowing through the discharge tube. The pulse repetition frequency was 1 cps, gas flow was above 25 liters/min, peak amplitude was approximately 400A, with a rise time of 1.6 microsecond, and an overall duration of 3.6 microseconds. Oscillations were obtained at 7 wavelengths between 21 and 32 microns. With a constant average gas pressure, the total output power from the laser increased with charging voltage and reached a saturation value at 2.4-torr pressure and 27 kV. Data are tabulated and results discussed.

E.E.B.

**N65-20175** Services Electronics Research Lab., Baldock (England).

**A COMPACT PULSE GENERATOR FOR DRIVING GALLIUM ARSENIDE LASERS AT ROOM TEMPERATURE**

R. F. Broom *In its S.E.R.L. Tech. J.*, Vol. 15, No. 1, Feb. 1965 [1965] 7 p refs Submitted for Publication (See N65-20166 10-16)

A simple apparatus employing a mechanical contact in conjunction with a low inductance circuit was found capable of generating current pulses of up to 2400 A with a rise time in the region of 20 nsecs and at a pulse repetition frequency of between 10 and 100 cps. Used to drive a GaAs laser at room temperature of junction area  $1.6 \times 10^{-3} \text{ cm}^2$  at a current of 800 A, a peak light output power of 5 watts was obtained. Together with its associated transistor circuits the device measures only 2 1/8 in. in diameter by 6 in. in length. Current consumption is low enough for it to be powered from a dry battery.

Author

**N65-20176** Services Electronics Research Lab., Baldock (England).

**A SEMICONDUCTOR LASER ARRAY**

R. F. Broom *In its S.E.R.L. Tech. J.*, Vol. 15, No. 1, Feb. 1965 [1965] 4 p Presented at I.E.E. Conf. on Lasers and their Applications, London, 29 Sep. 1964 (See N65-20166 10-16)

A method of producing a parallel beam from a laser array and the construction of an optical system of 10 lasers is described. Each laser diode is 2 mm long and 1 mm wide across the emitting surface. Preliminary measurements on single units indicated that the array will give a peak light output of 1 kW and a mean output approaching 10W. The measured bandwidth was 5 milliradians in a horizontal plane and 2 milliradians in a vertical plane. When driven with 240 A, 0.7  $\mu\text{sec}$  pulses, the peak light power output was 500W.

E.E.B.

**N65-20177** Services Electronics Research Lab., Baldock (England).

**DESIGN OF A COMPACT 100-WATT GaAs LASER TRANSMITTER**

K. G. Hambleton and F. E. Birbeck *In its S.E.R.L. Tech. J.*, Vol. 15, No. 1, Feb. 1965 [1965] 9 p refs Presented at I.E.E. Conf. on Lasers and their Applications, London, Sep. 1964 (See N65-20166 10-16)

The design of a compact GaAs laser transmitter with performance sufficient to illustrate the potential of lasers is described. The properties considered desirable for general applications are enumerated. A limit of peak power of 100 watts was chosen for a single GaAs laser, which was set by the mean Joule heating in the laser series resistance. The laser, cooling system, and pulse generator designs are detailed. The final pulse generator circuit using the silicon controlled rectifier gave 200 A pulses 0.5 microseconds long and at repetition frequencies of over 10 kc/sec.

E.E.B.

**N65-20300#** Northrop Space Labs., Hawthorne, Calif  
**INVESTIGATION OF THE SCATTERING OF A LASER BEAM BY THE ELECTRONS OF A PLASMA** Final Technical Report

D. W. Mc Morris and H. N. Olsen Dec. 1964 45 p refs (Contract AF 49(638)-1336) (NSL-64-168-1; AFOSR-65-0033; AD-610167)

The radiation scattered from the beam of a laser by free electrons of a test plasma has been investigated as a possible tool for plasma diagnostics at electron densities in the range of  $10^{16}$  to  $10^{17} \text{ cm}^{-3}$  and temperatures from  $10000^\circ$  to  $20000^\circ \text{ K}$ . A perturbing effect on the plasma background radiation was observed which masked the expected Thomson scattering. This perturbation is interpreted as a plasma heating resulting from energy transferred to the plasma from the laser beam by coupling of the electromagnetic field with the plasma charged particles.

Author

**N65-20391** Library of Congress, Washington, D. C. Aerospace Technology Div.

**ELECTRON-BEAM-PUMPED LASER**

*In its Foreign Sci. Bull.*, Vol. 1, No. 1, Jan. 1965 [1965] p 1-3 refs (See N65-20390 10-34)

Soviet research on the electron-beam-pumped semiconductor laser is reviewed, from the early unsuccessful attempts to the development of an operating device.

Author

**N65-20562#** Perkin-Elmer Corp., Norwalk, Conn. Electro-Optical Div.

**INVESTIGATION OF TECHNIQUES FOR MODULATING AND SCANNING A LASER BEAM TO FORM A VISUAL DISPLAY** Final Report, Jun. 1963-Jun. 1964

Paul R. Yoder, Jr. et al Griffiss AFB, N.Y., RADC, Jan. 1965 352 p refs *Its Report*-7600 (Contract AF 30(602)-3122) (RADC-TDR-64-365; AD-612725)

Various techniques which might be used to modulate and deflect a laser beam in response to an input video signal to form a projected visual display containing  $10^6$  resolved information bits at 30 frames per second are considered. The Pockel cell using potassium dihydrogen phosphate is considered. The design and experimental evaluation of a breadboard three-pass KDP modulator conducted under this investigation are summarized. This type of device should be capable of providing the required performance. Slow scanning of the beam at 30 cycles per second is found feasible using a piezoelectrically driven nodding mirror scanner. Two specially designed and slightly different scanners of this basic type are described. Under sawtooth waveform excitation of 150 volts peak to peak, beam deflections of  $\pm 15$  milliradians linear to  $\pm 2\%$  for 90% of each cycle were obtained without excessive distortion of the mirror surface.

Author

**N65-20605# Naval Ordnance Lab., White Oak, Md.  
TRANSMISSION OF GREEN LASER LIGHT (5300Å)  
THROUGH WATER**

D. E. Matlack, H. A. Templin, and W. W. Talbert Jan. 1965  
27 p refs  
(NOLTR-64-179; AD-610071)

The extinction coefficient of filtered Potomac River water was measured at the frequency doubled neodymium green laser wavelength of 5300Å. Measurements were conducted in situ at the David Taylor Model Basin (DTMB). Extinction coefficients of 0.097, 0.104, and 0.119  $\text{m}^{-1}$  were measured on June 4, 5 and 8, 1964, respectively. The increase in attenuation with time is confirmed by filtered arc light measurements, and is attributed to contamination of the water after the basin filtration system was turned off. Scattering experiments indicate that the aureole effect for the highly collimated laser beam was small over the 200-meter range of the measurements. Author

**N65-20780** Joint Publications Research Service, Washington, D. C.

**STIMULATED EMISSION FROM GaAs P-N JUNCTIONS**  
Wu-lin Liu *In its* Transl. on Communist China's Sci. and Technol., No. 163 24 Mar. 1965 p 104-110 ref Transl. into ENGLISH from K'o-hsueh Tung Pao (Peking), no. 1, Jan. 1965 p 65-67 (See N65-20778 10-34) CFSTI: \$4.00

The characteristics of a GaAs laser capable of producing stimulated emission are discussed. The narrowing of spectral lines, decrease of the light bundle angle, and the sudden increase of the radiation intensity as the current is increased through the threshold value were considered. The variation of the threshold current at 77° and at 20° K was also studied. The p-n junctions were prepared by the diffusion method. The Zn was made to diffuse into n-type GaAs, in which the initial Te impurity density varied from  $5 \times 10^{17}$  per cc to  $1.5 \times 10^{18}$  per cc. The diffusion length was approximately 5 mm. Threshold currents in the range of 2600 to 6000 amp/cm<sup>2</sup> were obtained for different specimens of the p-n junctions. E.E.B.

**N65-20782** Joint Publications Research Service, Washington, D. C.

**SEPARATION OF WAVE MODES OF GASEOUS LASER**  
Hsi-ming Kuo, Shu-sheng Yu, Chou Hang, and Hsueh-ming Yen *In its* Transl. on Communist China's Sci. and Technol., No. 163 24 Mar. 1965 p 116-121 refs Transl. into ENGLISH from K'o-hsueh Tung-pao (Peking), no. 1, Jan. 1965 p 69-70 (See N65-20778 10-34) CFSTI: \$4.00

A method of separating the single wave modes, and observations of the output pattern of single wave oscillation modes are presented. An external type He-Ne mixture gaseous laser was used. The quartz discharge tube with a Brewster window was 220 cm long, 8 mm in radius, with pressure of 1.1 mm Hg. The helium-to-neon pressure ratio was approximately 10:1. The resonant cavity was composed of two spherical reflectors of high reflectivity, with a radius of curvature of 220 cm and a spacing between them of 245 cm. It was excited by high frequency external electrodes with an output wavelength of 6328 Å. The discharge length was shortened to separate the longitudinal modes, until the beat signal of two neighboring modes completely disappeared. This assured that there was only one longitudinal mode taking part in the oscillation. E.E.B.

**N65-21141#** Joint Publications Research Service, Washington, D. C.

**EXPERIMENTAL NONLINEAR OPTICS**

S. A. Akhmanov and R. V. Khokhlov 6 Apr. 1965 30 p Transl. into ENGLISH from the book "Problemy Nelineynoy Optiki" Moscow, 1964 p 255-282

(JPRS-29459; TT-65-30665) CFSTI: \$2.00

The nonlinear effects discussed have to do with the reactive nonlinearity of optically transparent media. The results presented are based either on model concepts or on general considerations based on statistical theory. The nonlinear effects considered are first-order effects with respect to the small parameters—the anharmonicity parameter and a parameter that characterizes the ratio of charged particle displacement to the wavelength. Consideration of saturation effects in negative temperature systems, related directly to laser theory have been omitted. Also, the nonlinear effects in semiconductors have been omitted. E.E.B.

**N65-21219#** Library of Congress, Washington, D. C. Aerospace Technology Div.

**GAS BREAKDOWN IN A LASER BEAM**

Simon Kassel *In its* Foreign Sci. Bull., Vol. 1, No. 3, Mar. 1965 p 1-8 refs (See N65-21218 11-34) CFSTI: HC \$3.00/MF \$0.50

A review is presented of recent Soviet research on gas breakdown in the focused laser beam. This problem is explored by several distinct theoretical methods, drawing specialists from different fields, and by independent experimental investigation. Author

**N65-21308#** General Dynamics/Electronics, Rochester, N. Y. Research Dept.

**LASER MODULATION AT THE ATOMIC LEVEL** Monthly Report No. 7, 1-31 Jan. 1965

E. G. Brock, F. C. Unterleitner, Y. C. Kiang, and J. F. Stephany [1965] 14 p ref  
(Contract NASw-1008)

(NASA-CR-57823) CFSTI: HC \$1.00/MF \$0.50

The emission of 1 wt% Nd<sup>3+</sup> in yttrium aluminum garnet (YAG) in the wavelength range 1.05μ to 1.08μ was studied as a function of temperature between +100° and -196° C, giving a clearer picture of the reasons for the unusual reduction of YAG:Nd<sup>3+</sup> laser threshold with lowering of temperature near room temperature. The shift of laser emission with homogeneous pulsed magnetic fields was also studied over the same temperature range by time-resolved spectroscopy. For the transition responsible for laser emission above -50° C the highest gain Zeeman component has an apparent g value of -2.51, with a weaker +2.51 component observable at the low temperature end of the range over which this transition oscillates. The highest gain component of the low temperature laser transition has a g value of +1.94. Author

**N65-21342#** Philco Corp., Blue Bell, Pa. Applied Research Lab.

**THEORETICAL AND EXPERIMENTAL INVESTIGATION ON MODULATION-INDUCING RETRODIRECTIVE OPTICAL SYSTEMS (MIROS)** Monthly Progress Report, 20 Dec. 1964-20 Jan. 1965

G. K. Chang and P. H. Cholet 15 Feb. 1965 7 p refs  
(Contract NAS5-9765)

(NASA-CR-57922; MPR-3) CFSTI: HC \$1.00/MF \$0.50

Experimental work on GaAs lasers, the generation of alkaline line by stimulated Raman emission, the band-edge modulator, and the cesium bulb are reported. GaAs lasers were prepared which lased at 77° K at 8340 Å with a threshold of  $4 \times 10^3$  amp/cm<sup>2</sup>, using 2 μsec pulses at a low repetition rate. Also, a negative resistance was obtained in the forward current-voltage characteristic of the cadmium-diffused diodes.

A typical diode will be insulating to 2 V before dropping back to 1.5 V and conducting. To improve the pumping efficiency of the ruby laser, a special silver plating was applied to the existing laser cavity with satisfactory results. The cesium sources previously used for optical pumping were replaced with sources using argon as the buffer gas to avoid the strong 8952 Å line of xenon. The degree of rf excitation was strongly dependent upon the argon pressure. The best sources (25% pumping efficiency) had pressures around 1 mm Hg. E. E. B.

**N65-21372#** Tokyo Univ. (Japan). Inst. of Space and Aeronautical Science

**BULLETIN OF THE INSTITUTE OF SPACE AND AERONAUTICAL SCIENCE, VOLUME I, NO. 1**

Koichi Oshima, Masao Yamamoto, Katsutaka Sugaya, and Yuko Oshima Jan. 1965 59 p refs In JAPANESE, ENGLISH summary

Applications of a Ne-He gas laser to conventional schlieren method and Mach-Zehnder interferometry are very successful. The high brightness of the laser light source results in such sensitive schlieren photographs that the maximum sensitivity obtained is actually limited by diffraction of the laser light beam due to the models. The high monochromaticity and brightness of the laser light make adjustments of Mach-Zehnder interferometers very easy, and high quality interferograms can be obtained for fields with very large optical path differences beyond millions of the fringe shifts. Such high interference of the laser light in Mach-Zehnder interferometry suggests several new applications—for instance, measurements of temperature fields in transparent liquid or solid and strain analyses of solid models. A few other laser applications to gasdynamic testing are proposed, including heterodyne detection of two laser lights to analyze an interference of light wave with a plasma. Author

**N65-21553#** Ohio State Univ. Research Foundation, Columbus. Antenna Lab.

**STUDIES IN PARTIAL COHERENCE AND NONLINEAR OPTICS**

John G. Meadors (Ph.D. Thesis) 30 Nov. 1964 111 p refs (Contract AF 33(657)-10824) (Rept.-1579-17; AD-460733)

Two important topics in physical optics are considered: optical coherence, and nonlinear interaction of light waves in dielectrics. The conditions on the optical fields necessary for ergodicity are specified. The detector response is found to be of fundamental significance in the interpretation of experimental results. The interpretation of information, obtained in typical experiments, on the coherence properties of an optical field is discussed. A quantum mechanical description of interference phenomena between independent laser sources is given. It is shown that coherent states of the radiation field, which are not energy states, give rise to interference effects whose description formally corresponds to the classical treatment of the fields. If the state of the radiation field corresponds to mixed energy states, the interference is due to the intensity correlation at two space-time points. The importance of crystal orientation in the achievement of nonlinear interactions in dielectrics is discussed and demonstrated through the analysis of realistic experiments. A theory of nonlinear interactions in dispersive dielectrics is given, in which beam divergence and frequency spread in the laser fields are treated. The results of the analysis specify the limitations of the plane-wave theory. The role of coherence on nonlinear interactions is considered. Author

**N65-21554#** Ohio State Univ. Research Foundation, Columbus. Antenna Lab.

**A STUDY OF THE FOCUSING AND COLLIMATION PROPERTIES OF THE PULSED MULTI-MODING RUBY LASER**

Neil R. Kilcoyne (M.S. Thesis) 31 Dec. 1964 52 p refs (Contract AF 33(657)-10824) (Rept.-1579-19; AD-460461)

Classical coherence theory as presented by Wolf with the modification proposed by Neugebauer is used to mathematically and experimentally describe the collimation and focusing of the time averaged intensity of pulsed multimode laser radiation. Measurements of the double-slit Fraunhofer pattern and the near- and far-zone intensity patterns were made on two pulsed ruby lasers by both still and streak photography to examine the spatial coherence and the collimation of the beam. Results showed that the time-averaged collimation and focusing characteristics of the beam can be treated as the superposition of noncoupled spatially coherent modes. Author

**N65-21555#** Ohio State Univ. Research Foundation, Columbus. Antenna Lab.

**TEMPORAL DEPENDENCE IN LASER-INDUCED GAS DISCHARGES**

R. G. Tomlinson 15 Mar. 1965 14 p refs (Contract AF 33(615)-2287) (Rept.-1935-2; AD-460460)

This report investigates the temporal dependence of laser-induced gas breakdown. A correlation is observed between the laser pulse amplitude and gas pressure and the time interval from the initial incidence of the pulse until a visible discharge occurs. This time interval can be so great that the visible discharge occurs when the intensity of the laser light in the focal region is only a fraction of what its peak intensity had been previously when no discharge occurred. These observations are consistent with the assumption that a small initial ionization (possibly caused by multiphoton absorption) grows to visible discharge densities in a cascade process involving electron-ion and electron-neutral molecule collisions in the presence of the laser field. Author

**N65-21558#** Raytheon Co., Waltham, Mass. Research Div. **INVESTIGATION OF CERTAIN BASIC PROBLEMS IN SOLID STATE AND GASEOUS OPTICAL MASERS** Final Report, Dec. 1, 1963-Sep. 30, 1964

C. Tang Nov. 1964 134 p refs (Contract AF 19(628)-3862) (S-702; AFCRL-64-946; AD-612707)

This report gives results of an experimental and theoretical investigation of the spectral and transient characteristics of solid-state and semiconductor lasers and also a theoretical study of the nonlinear interaction of coherent lightwaves due to the higher order coherent Raman effects. It includes also a description of the detailed results obtained in a successful attempt at improving both the output spectra and the spiking characteristics of ruby and  $\text{CaWO}_4\text{ND}^{3+}$  lasers and some preliminary experimental results of higher order coherent Raman processes confirming that volume amplification of coherent lightwaves via the Raman processes have been observed. TAB

**N65-21673#** Sperry Gyroscope Co., Great Neck, N. Y. Radiation Div.

**DESIGN CRITERIA STUDY FOR HIGH POWER HIGH VOLTAGE RESEARCH FACILITY** Final Engineering Report, 1 Jul. 1963-30 Sep. 1964

Oct. 1964 74 p (Contract DA-36-039-AMC-03199(E)) (EB-5288-0536; AD-458408)

A survey was made of the anticipated requirements for high-voltage, high-power, and high-energy research facilities during the 1970 decade. The areas surveyed include high-power radar and communication components, lasers, plasmas, etc. A preliminary design of a facility to meet these needs was

made. The facility includes a 500-kV 10-A dc power supply, a  $6.25 \times 10^6$  joule energy storage bank, a 1000-kV dc high potential tester, modulators, rf drivers, microwave resonant rings, etc. An economic analysis of the initial facility cost and the annual operating costs has been made, and a complete schedule for the facility construction is presented. Author

**N65-21691#** Conduction Corp., Ann Arbor, Mich.

**COHERENT LIGHT INVESTIGATION, VOLUME III**

G. Cochran, L. Cutrona, A. Ingalls, I. Kay, A. Sabersky et al Wright-Patterson AFB, Ohio, ASD, Oct. 1964 111 p refs (Contract AF 33(615)-1014) (D-52110-72-T80-110; AD-610082)

A new theory is presented for analyzing optical systems in terms of transfer functions and optical systems employed normally with coherent light. Also, the general theory of holograms and complex spatial filters are discussed. The production of two- and three-dimensional holograms using coherent light, and its implications for synthetic antenna applications, complex filters, matched filters, and general filtering systems are described. Practical details on experimental results are also given. Discussions are presented on the use of a laser for measurements of target acceleration and rotation rates and on the problem of testing large reflective optics. Author

**N65-22027#** American Optical Co., Southbridge, Mass. Research Div.

**PREPARATION OF PLATINUM-FREE LASER GLASS** Semi-Annual Technical Report, 1 Aug.-31 Dec. 1964

W. R. Prindle, G. A. Granitsas, and C. G. Silverberg [1964] 37 p refs

(Contract Nonr-4656(00); ARPA Order 306-62) (SATR-1, AD-457331)

Results are reported of a development program on an all-ceramic melting system for the production of a moderate amount of high quality, platinum-free, laser glass in a batch or semicontinuous manner utilizing high purity corrosion resistant ceramics, effective stirring, and some form of casting technique. Also reported are results of studies on the improvement of platinum for use in laser production without causing inclusions. Design specifications such as maximum absorption, glass composition, refractive index, absence of metallic inclusions, and absence of striae, are described. S.C.W.

**N65-22072#** Ohio State Univ. Research Foundation, Columbus. Antenna Lab.

**BREAKDOWN OF ARGON BY NEODYMIUM AND RUBY LASER PULSES**

R. G. Tomlinson, E. K. Damon, and H. T. Buscher 28 Jan. 1965 9 p refs

(Contract AF 33(615)-2287) (Rept.-1935-1; AD-460459)

This report contains the first reported quantitative data on gas breakdown by radiation from a Q-switched neodymium laser. A comparison of the power densities required to produce breakdown in argon with a ruby laser pulse and with a neodymium laser pulse show larger breakdown power densities at the ruby frequency. The average breakdown densities at the two frequencies strongly indicate a frequency cubed relationship between the breakdown power density and the frequency of the laser radiation. Author

**N65-22139#** Rochester Univ., N. Y. Inst. of Optics  
**A STUDY OF THE EMISSION FROM A TRAVELING WAVE RUBY LASER**

Claude B. Smoyer (M.S. Thesis) Nov. 1964 87 p refs (Contract AF 19(628)-2360) (AD-610865)

Theoretical predictions have indicated that spectral narrowing of the emission from a ruby laser should occur for a traveling wave laser cavity. Evidence of such spectral narrowing is presented. A comparison of equivalent traveling and standing wave cavities shows that for similar excitation, spectral narrowing of better than a factor of four can be achieved. However, multimoding in this experimental arrangement is still strongly evident. Results of preliminary experiments in "Q" switching the traveling wave cavity are also presented. These results are inconclusive, but do show the need for a more sophisticated experimental procedure for obtaining optimum results from a "Q" switched traveling wave laser cavity. Author

**N65-22210#** Electro-Optical Systems, Inc., Pasadena, Calif.  
**OPTICAL SURVEILLANCE COMPONENT TECHNIQUES** Final Report, 22 Oct. 1962-22 Nov. 1963

Paul C. Fletcher, Mani L. Bhaumik, David L. Weisman, Burt L. Cooke, David L. Fridge et al Griffiss AFB, N.Y., RADC, Jan. 1965 173 p refs

(Contract AF 30(602)-2914)

(RADC-TDR-63-557; EOS-3460-Final; AD-612359)

The techniques and components necessary for the implementation of an optical Doppler surveillance system are discussed. Specifically, the requirements of an optical transmitter are set down. Efforts to use chelates to achieve both a gaseous narrow band oscillator and a high power amplifier are described. The description of laser action in several chelates of europium is included with the theory of why some chelates lase and others do not. The incorporation of an oscillator and an amplifier into a transmitter is described using Nd:CaWO<sub>4</sub> as the oscillator and Nd glass as the amplifier. Gains of 10 dB were achieved in a single-pass amplifier, which is 8 inches long and pumped with 6000 joules. The problems of isolation of the oscillator and amplifier are discussed, and a breadboard model of a Faraday isolator using flint glass was built with greater than 30-dB isolation and less than 1-dB insertion loss. The problems of optical heterodyne receiving are discussed. Measurements on mono-moding of lasers, stability and stabilizing of lasers, modulation of lasers by end reflectors variation, for both amplitude and frequency modulation are discussed. A description of a possible wideband heterodyne receiver is presented. Measurements are made using a 1 to 2 Mc/second Kerr cell amplitude modulator as a target simulator. Author

**N65-22221#** Air Force Cambridge Research Labs., Bedford, Mass. Terrestrial Sciences Lab.

**A COMPENDIUM OF PAPERS IN THE FIELDS OF GEODESY AND PLANETARY GEOMETRY PREPARED AT AFCRL DURING 1963** Special Reports No. 18

Owen W. Williams, ed. Jan. 1965 178 p refs (AFCRL-65-14; AD-611003)

This compendium presents a series of selected technical papers prepared by scientists of Air Force Cambridge Research Laboratories during 1963 in the fields of geodesy and planetary geometry. These papers describe research activities in the areas of satellite geodesy, airborne gravimetry, instrumentation calibration via satellite, laser geodesy, land gravity instrumentation and programs, and selenodesy (geodesy of the moon). Illustrations show recent geodetic instrumentation developments and technique configurations. Author

**N65-22250#** Westinghouse Electric Corp., Baltimore, Md. Surface Div.

**INVESTIGATION OF GAS IONIZATION PHENOMENON AT OPTICAL AND IR FREQUENCIES** Second Interim Technical Report, 11 Aug.-11 Dec. 1964

Vincent Dovydaitis, Jr. Griffiss AFB, N. Y. RADC, Feb. 1965  
86 p refs  
(Contract AF 30(602)-3332)  
(RADC-TR-64-568; AD-612498)

The status of the work on ruby laser induced gas ionization is reported. Experimental measurements of the focused spot diameter, breakdown emission, ionization times, and nonattenuation ionization are presented. The theoretical study results obtained to date in the areas of nonlinear ionization initiation and the extension of the microwave breakdown theory are discussed. Author

**N65-22274#** Westinghouse Electric Corp., Pittsburgh, Pa. Research Labs.

**VAPORIZATION OF MATERIALS BY Q-SPOILED LASER PULSES FOR SPECTROSCOPIC ANALYSIS** Scientific Report No. 1

P. F. Browne 24 Aug. 1964 15 p refs Revision of Westinghouse Res. Memo 64-9C1-155M1  
(Contract AF 19(628)-4184)  
(AFCLR-64-871; AD-613536)

This report is a preliminary theoretical analysis of the vaporization of materials by focused high intensity radiation and of the optical emission and absorption properties of the resulting vapor. Author

**N65-22300** Army Electronics Labs., Fort Monmouth, N. J. **DIRECT MODULATION OF A He-Ne GAS LASER**

Ernst J. Schiel / In Army Dept. Army Sci. Conf. Proc., Vol. II [1965] p 321-329 (See N65-22275 12-34)

Experiments were performed with two different types of He-Ne lasers. The first set of experiments was taken with a laser with confocal mirror configuration emitting in the near infrared at 11530 Å. Pump power threshold for stimulated emission was 17% of the maximum pump power and the length of the plasma column was 35 cm. By modulating the pump power between threshold and maximum, 100% amplitude modulation was achieved. The second set of measurements was made with a laser with hemispherical mirror arrangement emitting in the visible part of the spectrum at 6328 Å. For modulating experiments the pump power was adjusted to a certain carrier level (bias) and then a modulation of 1 kc was applied upon this bias. A completely sinusoidal light modulation resulted if only a small percentage of pump power was modulated. Details of the experiments and the characteristics of both lasers are given. An experimental communications system for one audio channel was built by simply modulating the transmitter as it was originally designed. The receiver consists of the same photodiodes used during the experiments backed up with sufficient amplification to drive the speaker. E.E.B.

**N65-22323#** Spectra-Physics, Inc., Mountain View, Calif. **HIGH POWER GAS LASER IN THE VISIBLE** Quarterly Progress Report, 1 Oct.-30 Dec. 1964

Arnold L. Bloom and Jerald E. Roseblum [1964] 31 p  
(Contract DA-28-034-AMC-00194(E))  
(QPR-2; AD-613197)

Experimental results are reported for cw operation in argon and krypton as a function of magnetic fields. These experiments were performed in a tube 1.5 mm in diameter and 28 cm long. A comparison is made between the results obtained with internal mirrors and those obtained with Brewster angle windows. Experiments were carried out on mixtures of gases to determine whether certain types of mixtures enhance the power output of given laser transitions, and whether two laser gases could be made to operate simultaneously. It was found that in the former case the addition of mercury or neon to krypton enhanced laser operation in krypton, but

that in the latter case mixtures of krypton and argon did not provide stable discharges. Spectroscopic experiments in argon and krypton lasers verified the  $I^4$  and  $L^2$  relationships at moderate powers and indicated that substantial resolution of Zeeman components occurs in magnetic fields of the order of 1000 gauss. Author

**N65-22518#** Purdue Univ., Lafayette, Ind. Quantum Electronics Lab.

**D. C. POLARIZATION IN A NONLINEAR DIELECTRIC MEDIUM AT OPTICAL FREQUENCIES** Semiannual Technical Summary Report No. 1, 1 Apr.-31 Dec. 1963

Mahadevan Subramanian and A. K. Kamal Feb. 1964 93 p refs  
(Contract Nonr-1100(24); ARPA Order 306-62; Proj. Defender)  
(TR-EE-64-5; AD-433218)

The dc polarization that is developed in a nonlinear dielectric medium when a high intensity laser beam propagates through is investigated. The nonlinear dielectric medium chosen is crystalline quartz. The relationship between laser intensity and dc polarization is established mathematically for two cases of propagation. The linear relationship between the laser intensity and the dc voltage output of the quartz detector is verified. The possibility of using this principle to build a transmission type of meter for measuring power in high power laser pulses is presented. Author

**N65-22702#** Space Technology Labs., Redondo Beach, Calif. **RESEARCH OF LASER PUMP AND ENERGY STORAGE TECHNIQUES**

F. N. Mastrup, R. F. Wuerker, and J. J. Caldwell, Jr. Feb. 1965 133 p refs  
(Contract AF 33(615)-1072)  
(AFAL-TR-65-22; AD-611771)

A fast high radiance ablating laser pump of novel design has been constructed and its radiative characteristics have been determined. Performance of the lamp for exciting a ruby crystal of 0.580-in. diameter and 8-in. length has been established. Total stimulated emission energies in the range 10 to 30 joules, depending on individual rods, have been verified. Laser energy was emitted in times near 25 microseconds. The stimulated emission pulse consisted of a series of spikes highly regular with respect to their mutual separation and peak power. Maximum measured peak spike power was 2.5 X 1 000 000 watts. Author

**N65-22732#** Army Dept., Washington, D. C. **ARMY SCIENCE CONFERENCE PROCEEDINGS. VOLUME I: PRINCIPAL AUTHORS A THROUGH H**

[1964] 526 p refs Conf. held at U.S. Military Acad., West Point, N. Y., 17-19 Jun. 1964  
(AD-611432)

Papers given at the Army Science Conference are presented arranged by principal authors A through H. For individual titles see N65-22733-N65-22765.

**N65-22742** Army Electronics Labs., Fort Monmouth, N. J. **THE USE OF INTENSE PINCH DISCHARGES FOR LASER ILLUMINATION**

R. G. Buser, J. J. Kainz, and J. J. Sullivan / In Army Dept. Army Sci. Conf. Proc., vol. I [1964] p 121-134 refs (See N65-22732 12-34)

Two types of gas discharge are studied as light sources for use in optical pumping of laser materials: the types are theta pinch without electrodes, and linear pinch with electrodes. Experimental results show that pinch discharges can be used effectively as light pumps which are free of certain limitations characteristic of the standard light sources for optical pumping. It was found that high repetition rates are



obtainable for certain military applications. The fast pinch discharge mechanism also may eliminate the need for mechanical or electronic Q spoiling. In testing ruby, terbium, and neodymium as laser materials, it appeared that the light source must be tailored for optimum performance. It may be possible to develop new laser materials which match the properties of pinch discharges. J.M.D.

**N65-22759** Army Electronics Labs., Fort Monmouth, N.J.  
**RUBY LASER WITH VIBRATING REFLECTOR**

E. A. Gerber and E. R. Ahlstrom / In Army Dept. Army Sci. Conf. Proc., Vol. I [1964] p 375-389 refs (See N65-22732 12-34)

From observations of the character of the temporal output of the ruby laser and of the energy output influenced by the vibrating mirror, it was concluded that the Statz-de Mars theory is based on the assumption of the existence of a single mode in the cavity and predicts equally spaced spikes with exponential decay. The vibrating mirror provides a means for obtaining single mode operation in a solid state laser. However, recent results show that spike patterns do not necessarily indicate single-mode operation. It was shown that spiking is completely regular at lower pumping levels and loses some of its regularity at higher pumping levels. This fits well into the single-mode picture, since higher pumping energy causes the appearance of more modes in the cavity. Further, the dominant axial mode has the lowest losses in the cavity, and higher order longitudinal and transverse modes have increasing losses. If higher order modes are suppressed by the vibrating mirror, more energy will be dumped into the low-loss dominant mode and the efficiency of the laser will increase. E.E.B.

**N65-22851#** Ohio State Univ. Research Foundation, Columbus.  
Antenna Lab.

**MULTIPHOTON BREAKDOWN TRIGGER**

R. G. Tomlinson 18 Mar. 1965 14 p refs  
(Contract AF 33(615)-2287)  
(Rept.-1935-3, AD-461481)

The conditions under which multiphoton ionization could trigger the breakdown of the noble gases subjected to ruby laser radiation are derived. The relative ionization rates in these gases are dependent on pressure and focal volume, as well as photon flux. The specific prediction is made that for sufficiently low pressure, small focused spot size, and small focal volume the relative ease of initiating breakdown in argon and neon should be reversed. Author

**N65-22879#** Naval Ordnance Test Station, China Lake, Calif.  
Test Dept.

**DESIGN FOR A LASER RANGEFINDER**

T. G. Bergman Dec. 1964 72 p refs  
(NAVWEPS-8674; NOTS-TP-3724; AD-611001)

In order to design a laser rangefinder, it is necessary to predict the effect that a change of any variables will have on the expected performance. Preliminary aspects of the overall design are discussed giving a general background in the current state of the art. A derivation of the relationship between the parameters in what is generally called the range equation is shown. Methods for determining the parameters are presented and it is shown how the parameters affect the performance specification. The range equation is computed and the design for a rifle rangefinder is presented. The rifle rangefinder is a portable instrument designed to be mounted on a rifle in place of the usual telescopic sight. It is extremely lightweight (less than 5 lb) and sets the rifle to the correct elevation semiautomatically. Author

**N65-22896#** Minnesota Univ., Minneapolis. Electrical Engineering Dept.

**FIELD PATTERNS IN A RUBY LASER**

R. R. Collins and A. Hordvik [1963] 58 p refs  
(Contract Nonr-710(61))  
(TR-1; AD-612177)

Discussion is first given of the off-axis modes and of the mode selection mechanism. Experimentally it is then shown that radiation did appear at discrete angles with the axis, but some modes that were expected to be seen were not observed. Diffraction patterns were found and they are explained as Fabry-Perot or Fraunhofer patterns. Surface patterns were investigated, and there seemed to be a close connection between the asymmetric distribution of the active region and the occurrence of off-axis modes. The axial and off-axis modes were found to be polarized in the same plane within experimental error. Threshold and delay times were investigated, and good agreement was found between observed data and approximated theoretical calculations. Finally it was found that the intensity of the axial modes increases at a slower rate with input energy when the off-axis modes start occurring. A qualitative explanation is given for this. TAB

**N65-22933#** Technical Operations Research, Burlington, Mass.

**THE INVESTIGATION OF PASSIVE LASER Q-SWITCHING Semiannual Summary Report, 1 Jul. 1963-1 Jan. 1964**

J. I. Masters, P. Kafalas, and E. M. E. Murray 31 Jan. 1964 11 p  
(Contract Nonr-4126(00))  
(TO-B-64-15; AD-609643)

The ability of organic blue dyes and dye solutions to function as possible laser Q-switch materials was studied. Victoria Blue B dye was found to be a successful material when employed as a thin film on an optical flat glass substrate. Results of a comparison of switching speeds of Victoria Blue B film and a synchronized spinning prism indicated that the giant pulse output in each was about the same. The effect of the dye film outside the laser resonator was tested using a spinning prism Q-switch setup. No real difference in pulse height could be measured. In view of the large number of available laser photons per dye molecule overwhelming the passive films, several possible switching processes were studied. Results indicated that a two photon process may occur that could contribute to molecular dissociation. Several solutions, including Victoria B Blue, were tested in acetone and chlorophyll in water. A definite Q-switching effect was observed with both these solutions; however, efficiency was considerably below that of the dye film. The most efficient solution tested was Methylene Blue in water, which had a Q-switching efficiency about five times greater than the other solutions. S.C.W.

**N65-22952#** Korad Corp., Santa Monica, Calif.

**INORGANIC LASER MATERIALS Interim Engineering Report, 1 Aug.-30 Nov. 1964**

Wright-Patterson AFB, Ohio, AF Avionics Lab., 21 Dec. 1964 57 p refs  
(Contract AF 33(615)-1967)  
(AD-611416)

A study on the improvement of the crystal quality and performance efficiency of two host unary oxides  $Gd_2O_3$  and  $La_2O_3$ , and an evaluation of  $GdAlO_3$ ,  $MgO \cdot Al_2O_3$ , and  $BeO \cdot Al_2O_3$  as laser hosts are presented. Hybridized growth techniques were also studied in order to cope with the manifold problems associated with crystal growth of polynary oxides. Emphasized in the study on the improvement of crystal quality and size are two phases aimed at (1) the attainment of a higher level of purity in the starting material, and (2) the

attainment of a favorable heat balance which can be maintained under a steady-state condition of growth through a time interval commensurate with the size of crystal desired. A cation exchange purification method was developed for the removal of rare earth impurities. Studies are reported on the use of this method and other procedures in the separation of the most common impurities in  $Gd_2O_3$ . In conjunction with the second phase, boules were grown (undoped powder), 1/4 O.D., for heat balance study and acquaintance with problems pertaining to the annealing of specimens on site. Results of these studies are also reported. Spectroscopy, synthesis, crystal growth, and sorption/deterioration data are presented for the two host unary oxides and the host binary oxides.

S.C.W.

**N65-23135#** General Electric Co., Schenectady, N. Y. Research Lab.

**SEMICONDUCTOR DEVICE CONCEPTS Scientific Report No. 9 (Final)**

H. H. Woodbury, M. Aven, R. N. Hall, R. Baertsch, and F. K. Heumann Nov. 1964 27 p refs

(Contract AF 19(628)-329)

(AFRL-64-1007; AD-611630)

**CONTENTS:**

**SEMICONDUCTOR DEVICE CONCEPTS**

1. DIFFUSION OF Se IN CdS AND ZnSe H. H. Woodbury p 1-3 refs (See N65-23136 12-26)

2. SYNTHESIS AND PROPERTIES OF ZnSe-ZnTe MIXED CRYSTALS IN N- AND P-TYPE FORMS M. Aven p 5-13 refs (See N65-23137 12-26)

3. FM JUNCTION LASER R. N. Hall and R. Baertsch p 15-16 (See N65-23138 12-26)

4. THE PREPARATION OF  $GaAs_xP_{1-x}$  ALLOYS FOR LASER APPLICATIONS F. K. Heumann p 17-21 refs (See N65-23139 12-26)

**N65-23138** General Electric Co., Schenectady, N. Y. Research Lab.

**FM JUNCTION LASER**

R. N. Hall and R. Baertsch *In its Semicond. Device Concepts* Nov. 1964 p 15-16 (See N65-23135 12-26)

The fm junction laser structures were assembled and tested. Attempts to produce significant amounts of frequency modulation have thus far been unsuccessful due to excessive photocurrents in the modulating section. Author

**N65-23139** General Electric Co., Schenectady, N. Y. Research Lab.

**THE PREPARATION OF  $GaAs_xP_{1-x}$  ALLOYS FOR LASER APPLICATIONS**

F. K. Heumann *In its Semicond. Device Concepts* Nov. 1964 p 17-21 ref (See N65-23135 12-26)

Studies were continued on the halogen transport synthesis of GaAs and  $GaAs_xP_{1-x}$ . A number of GaAs ingots doped with tellurium were made. No correlation between electrical parameters and threshold currents was found. However, material with high threshold currents appears to have a large number of etch pits and cracks. This is also true for the  $GaAs_xP_{1-x}$  alloys. It thus appears that strains and imperfections in the crystals affect their laser behavior. Author

**N65-23285#** Electro-Optical Systems, Inc., Pasadena, Calif. **LASER BEACON STUDIES Final Summary Report, 30 Jun.-31 Oct. 1961**

Paul C. Fletcher 31 Oct. 1961 49 p

(Contract NAS8-2439)

(NASA-CR-62616; EOS-1920-Final) CFSTI: HC \$2.00/MF \$0.50

A description is given of the various components of a laser beacon together with problems encountered. The weight of the beacon proper for an uncooled system, excluding components for synchronization, is estimated to be about 22 pounds, and the volume about 650-cu in. Author

**N65-23316#** Massachusetts Inst. of Tech., Cambridge. Dept. of Geology and Geophysics

**OBSERVATIONS OF LIGHT SCATTERING IN SEA WATER**

Athelstan Frederick Spilhaus, Jr. (Ph.D. Thesis) Feb. 1965 246 p refs

(Contract Nonr-1841(74))

(AD-610126)

Combination of theoretical curves of the volume scattering function for several different monodisperse systems of Mie scatterers shows that, in a polydisperse system, the total scattering coefficient is determined by scattering at small angles to the direction of the incident beam; as particle sizes increase, rise in the volume scattering function at small angles increases. A method was devised to study shape of the volume scattering function for various types of sea water. Samples from surface waters and at depths up to 2000 meters were taken between Woods Hole and 26°N, 63°W. Water in the Sargasso Sea was found to have a significantly different scattering function from that of the slope and coastal waters. In a thermal front south of Bermuda the water along one isotherm was different from the average of that on either side of it. The total scattering coefficient showed banding on the continental shelf. The thermohaline front that exists on the edge of the shelf in winter is marked by a threefold change in the magnitude of the scattering. Using a laser as light source, forward scattering measurements were made to obtain relative total scattering. A continuous track was made between Woods Hole and Port Lewis, Mauritius. In the proximity of land twofold fluctuations of scattering in a range approximately three times higher than the nearly constant values found in mid-Atlantic were observed. Some fluctuations of the open sea values in the Atlantic were associated with thermal changes. Author

**N65-23435#** Library of Congress, Washington, D. C. Aerospace Technology Div.

**GIANT LASER PULSES WITH A PHOTOCHEMICAL SHUTTER**

John G. Kourilo *In its Foreign Sci. Bull.*, Vol. 1, No. 5 May 1965 p 21-23 refs (See N65-23432 13-34)

A review is presented of two Soviet studies on the role of metal-phthalocyanines in producing giant pulses from a ruby laser. A recent Soviet study established the effect of various metal components and concentration of the solutions on the characteristics of the laser pulses. Bleaching of the solutions by the coherent laser emission was interpreted as the result of accumulation of pigment molecules in the metastable (triplet) state. Author

**N65-23491#** Texas Univ., Austin. Quantum Electronics Research Lab.

**QUANTUM ASPECTS OF ELECTRICAL SCIENCE Final Report, 1 Apr.-30 Sep. 1964**

Arwin A. Dougal 1 Oct. 1964 104 p refs

(Grant AF-AFOSR-487-64)

(AFOSR-65-0248; AD-611338)

**CONTENTS:**

1. CHARACTERISTICS OF COUPLED OPTICAL RESONATORS R. B. Allen and A. A. Dougal p 1-25 refs (See N65-23492 13-16)

2. THERMAL PINCHING AT LOW FIELDS IN N-TYPE GERMANIUM D. K. Ferry and A. A. Dougal p 26-33 refs

(See N65-23493 13-26)

**3. EXPERIMENTS IN DIFFRACTION IMAGING OF COHERENT LIGHT IN THE MICROSCOPE** W. H. Carter and A. A. Dougal p 34-60 refs (See N65-23494 13-16)

**4. OUTPUT CHARACTERISTICS OF A HE-NE OPTICAL MASER OPERATING AT 3.39 $\mu$**  R. B. Allen and A. A. Dougal p 61-75 refs (See N65-23495 13-16)

**5. A TIME RESOLVED STUDY OF SECOND BREAK-DOWN IN SILICON SWITCHING TRANSISTORS** D. K. Ferry and A. A. Dougal p 76-83 refs (See N65-23496 13-26)

**6. POPULATION INVERSION AND OPTICAL MASER OSCILLATIONS IN MOLECULAR GASES** R. B. Allen and A. A. Dougal p 84-91 refs (See N65-23497 13-16)

**N65-23492** Texas Univ., Austin. Quantum Electronics Research Lab.

**CHARACTERISTICS OF COUPLED OPTICAL RESONATORS**

Raymond B. Allen and Arwin A. Dougal *In its Quantum Aspects of Elec. Sci.* 1 Oct. 1964 p 1-25 refs (See N65-23491 13-16)

The characteristics of coupled resonator systems were studied experimentally and analytically. It was observed that three different situations prevail depending on the degree of coupling between the resonators. The degree of coupling may be specified in terms of a coupling factor  $\gamma$  such that  $\gamma \leq R_3/R_2$  where  $R_i$  is the reflectivity of mirror  $M_i$ . The three situations which prevail may be noted as weak coupling ( $\gamma \approx 0$ ), intermediate coupling ( $\gamma \approx 1$ ), and strong coupling ( $\gamma > 1$ ). Weak coupling is approaching the situation where the external mirror  $M_3$  is absent from the system, i.e.,  $R_3 = 0$ . For this condition experimental results confirmed that the laser output beam is unchanged by slight variations in the optical path length of the external resonator. Strong coupling is approaching the situation where the common mirror  $M_2$  is absent from the system, i.e.,  $R_2 = 0$ . Slight variations in the external resonator optical path again do not modulate the output beam intensity but change the frequency of oscillation. For intermediate coupling, interference effects dominate and the laser output intensity is effectively modulated by small variations in the external resonator optical path length. E.E.B.

**N65-23494** Texas Univ., Austin. Quantum Electronics Research Lab.

**EXPERIMENTS IN DIFFRACTION IMAGING OF COHERENT LIGHT IN THE MICROSCOPE**

William H. Carter and Arwin A. Dougal *In its Quantum Aspects of Elec. Sci.* 1 Oct. 1964 p 34-60 refs (See N65-23491 13-16)

Several mathematical models of diffraction imaging are discussed based on the solutions of Maxwell's equations. The complexities of the mathematics require simplifying assumptions about the light field. The form of light which lends itself most readily to this treatment is a monochromatic, spatially coherent, plane wave. Since this is very closely realized by a gas laser beam, experiments in diffraction imaging of coherent light in the microscope were performed with a He-Ne gas phase laser oscillating at the 6328 Å line. This laser produces about 0.1 mW when operated with hemispherical interferometer and about 1 mW when operated with confocal. A photomicrograph taken of the Fresnel diffraction pattern formed in the object plane with laser illumination of the microscope substage condenser is shown. It was found that defocusing the microscope did not destroy the image formed by laser light nearly so readily as a conventional white light image. This effect is shown clearly by photomicrographs of sugar crystals illuminated with both light sources. E.E.B.

**N65-23495** Texas Univ., Austin. Quantum Electronics Research Lab.

**OUTPUT CHARACTERISTICS OF A HE-NE OPTICAL MASER OPERATING AT 3.39 $\mu$**

Raymond B. Allen and Arwin A. Dougal *In its Quantum Aspects of Elec. Sci.* 1 Oct. 1964 p 61-75 refs (See N65-23491 13-16)

A study of the effects on the output power of gas mixture ratio, total gas pressure, resonator geometry, and mirror reflectivities is reported for a He-Ne optical maser system operating at 3.39 microns. The primary purpose of the study was to maximize the 3.39-micron output of the laser within the limitations of the available mirrors. Among the characteristics observed was the ease with which lasing action at 3.39 $\mu$  could be obtained even where large losses were present. In order to obtain oscillation on a typical low gain line (0.6328 $\mu$ ) a stable resonator configuration with low diffraction losses was required. It has been observed that laser action takes place for mirror separations of over 15 meters using a stainless steel plane mirror and a 152-cm aluminized mirror. For this particular system, any mirror separation over 152 cm corresponds to a high diffraction loss unstable configuration. Substantial output of a few milliwatts was obtained with this arrangement. The power output was observed to go up when two plane mirrors are used over this distance. The maximum output was 16 mW for 10  $\mu$ sec duration pulsed and 10 mW continuous. Also, 2 mm Hg was the optimum pressure; the optimum ratio 5:1, He-Ne; and plane-parallel the optimum mirror configuration. E.E.B.

**N65-23497** Texas Univ., Austin. Quantum Electronics Research Lab.

**POPULATION INVERSION AND OPTICAL MASER OSCILLATIONS IN MOLECULAR GASES**

Raymond B. Allen and Arwin A. Dougal *In its Quantum Aspects of Elec. Sci.* 1 Oct. 1964 p 84-91 refs (See N65-23491 13-16)

The laser system previously reported was fabricated. Photograph and block diagram are included. The radius of curvature was changed from 1.35 m to 2 m because of the ready availability of the 2-meter mirrors. With a cavity separation of 1.35 m, the 2-meter radius of curvature mirrors form a stable system which makes more efficient use of the available volume of active material than the originally proposed confocal system with only a slight increase in the angular alignment requirements. Also, the peak reflectivity of the mirrors was changed from 3371 Å because of the difficulty encountered in obtaining such mirrors. Another change in the original system is the addition of a second variable leak valve and associated glass bulb. This provides the capability of investigating the laser characteristics of various gas mixtures. The details of the construction of the cathode, anode, and pumping arrangements are shown. E.E.B.

**N65-23622#** Army Missile Command, Huntsville, Ala. Electromagnetics Lab.

**A LITERATURE SURVEY ON THE ATMOSPHERIC EFFECTS ON THE PROPAGATION OF 1.06 MICRON LASER RADIATION**

Eddie L. Roy and George A. Emmons 8 Feb. 1965 58 p refs (RE-TR-65-3; AD-461778)

A literature survey on the effects of the atmosphere on laser energy propagation was performed. This memorandum presents the results. Special emphasis is given to the spectral region at 1.06 microns, since this is the region of interest for LASAM system applications. Transmission, absorption, scattering, and seeing effects are discussed for various weather conditions. Author

**N65-23722** Joint Publications Research Service, Washington, D. C.

**THE ELECTRON BEAM IN MODERN VACUUM METALLURGY**

B. Ye. Paton and B. A. Movchan *In its* The Use of Electron Beams and Laser in Ind. 4 May 1965 p 1-8 (See N65-23721 13-34)

The basic features of the electron beam heat source in connection with a high vacuum are considered for their metallurgical applications. Axial irradiation units and radial electron beam heaters are widely used in electron beam melting for obtaining pure niobium, tantalum, and many alloys based on these metals, as well as for refining and improving the properties of molybdenum, hafnium, zirconium, cobalt, nickel, iron, and copper. Electron beam refining of the indicated metals and their alloys lowers their hardness more than double and sharply increases their plasticity. It is concluded that the present electron beam melting in a vacuum of  $10^{-4}$  to  $10^{-5}$  mm Hg can be extended to a higher vacuum, thus inducing a higher degree of refining. G.G.

**N65-23723** Joint Publications Research Service, Washington, D. C.

#### THE INDUSTRIAL POSSIBILITIES OF LASERS

V. S. Zuyev *In its* The Use of Electron Beams and Lasers in Ind. 4 May 1965 p 9-16 (See N65-23721 13-34)

The capacity and applications of ruby and neodymium glass lasers are discussed. The bundle of light radiated by a laser can be focused onto an area determined by the focal length of the focusing lens and the angle of divergence of the laser beam. The diameter of the spot cannot be less than the wavelength of the light beam used. A ruby laser produces a diameter of 0.7 microns and the neodymium laser produces a diameter of 1.06 microns. Laser-pumping lasers can convert electrical energy directly into light with 20% to 30% efficiency. Of primary importance is the problem of stability of lasers under the influence of superpowerful light impulses. A laser machine was created and used to make a hole in a diamond die in less than a fraction of a second, and lasers were successfully used in the manufacture of contacts in miniature semiconductor instruments as well as in emission analysis of minerals. It was found that a laser with a huge impulse is less effective for burning holes than a laser under ordinary conditions, because the energy of the light impulse is absorbed by the plasmoid forming above the surface of a substance. G.G.

**N65-23836#** Library of Congress, Washington, D. C. Aerospace Technology Div.

**FOREIGN SCIENCE BULLETIN, VOLUME 1, NUMBER 4** Apr. 1965 71 p refs

(AD-460286) CFSTI: HC \$3.00/MF \$0.75

#### CONTENTS:

1. SOVIET LASER RESEARCH Charles Shishkevich p 1-13 refs (See N65-23837 13-16)

2. COMBUSTION INSTABILITY IN LIQUID-ROCKET AND AIR-BREATHING PROPULSION SYSTEMS Paul Vantoch p 14-23 refs (See N65-23838 13-33)

3. RECENT SOVIET EXPERIMENTAL STUDIES ON GAS DYNAMICS AND PROPERTIES OF GASES AT HIGH TEMPERATURES Alexis Baratoff p 24-28 refs (See N65-23839 13-33)

4. MORPHOLOGICAL FORMS IN HIGH POLYMERS Boris Ofrossimow p 29-40 refs (See N65-23840 13-18)

**N65-24195#** Corning Glass Works, N. Y.  
**GLASS LASER RESEARCH** Semiannual Technical Report, Jul.-Dec. 1964

R. D. Maurer, N. F. Borrelli, M. E. Vance, G. E. Stong, S. D. Sims (TRG, Inc.) et al 30 Jan. 1965 99 p refs  
(Contract Nonr-3833(00))  
(AD-612964)

Efficient utilization of neodymium glass lasers is investigated. Pump light damage to the cylindrical surface was due to scratches and imbedded particles. This damage is eliminated by chemical treatment of the surface. The mechanism of solarization is delineated, and the problem eliminated by pump light filtering with a minimal 15% loss in output. Improved performance was attempted by varying the external conditions. The efficiency of various pump bands is given in detail for matching light sources. Output is further maximized by varying the cavity coupling. From these output coupling data the first dynamic internal loss values for a near-perfect static medium are reported. They are about three times as large as the static losses. A detailed investigation to find an accurate value of the gain cross section (without assuming degeneracies) shows that a straightforward spectroscopic study can yield this quantity within a factor of two. Gain measurements in an amplifier are determined for eventual translation, through the gain cross section, into energy storage and real pump efficiency. Data are given on the time-resolved distortion of a pumped rod to determine the magnitude of this problem in preventing diffraction-limited operation. Author

**N65-24343#** Autonetics, Anaheim, Calif. Research, Engineering, and Reliability Div.

#### OPTICAL LASER AMPLIFIERS

E. L. Steele and W. C. Davis 1 Jun. 1964 13 p refs Presented at the IEEE 6th Region Ann. Conf., Salt Lake City, 29 Jul. 1964

A theoretical model for a laser amplifier is discussed in which the excited electron density in a host laser material is stimulated to radiate, thereby providing a source of optical energy. The photon density in the laser material is described by a continuity equation with this source term included and a gain expression derived for an amplifier system. The theoretical model is then compared with experimental data taken on a ruby amplifier driven by a Q-switched oscillator with stable output. The properties of the oscillator are due, in part, to a newly developed output coupler and a spinning rooftop prism for Q-spoiling. The gain of the system described is found to saturate at values between 5 and 7. This saturation appears to be due to a saturation effect caused by complete pumping of the system rather than being dependent upon the energy input to the flash lamp pump. Author

**N65-24550** Joint Publications Research Service, Washington, D. C.

#### THE DIVERGENCE OF RADIATION IN A HELIUM-NEON LASER

V. I. Makhovir and Ye. D. Protchenko *In its* Izv. VUZov: Radio-phys., Vol. VII, No. 6, 1964 13 May 1965 p 256-260 refs (See N65-24525 14-07) CFSTI: \$7.00

An analysis of output radiation divergence in helium-neon lasers with spherical reflectors is presented. Results of measurements of the lower modes and modes of higher orders confirmed the fact that in resonators with spherical reflectors and small diffraction losses, the quality factor can be increased by increasing the distance between the mirrors without changing the divergence. Also considered was divergence of single and two-beam patterns. It is concluded that divergence of each mode in a two-beam pattern is the same as that of similar modes generated under one-beam conditions. S.C.W.

**N65-24689#** Joint Publications Research Service, Washington, D. C.  
**BULGARIAN LASERS**

K. Kotsev 25 May 1965 5 p Transl. into ENGLISH from Otechestven Front (Sofia), 24 Mar. 1965 p 1-2 (JPRS-30232, TT-65-31073) CFSTI: \$1.00

A brief history on the development of lasers is given and the principle of forced radiation of energy through excited atoms is examined. Their use for piercing solid materials in machine building, in microelectronics, and as surgical tools in eye surgery, microbiology, etc., are discussed. Application of continuously operating gas lasers as radio transmitters, in communications transportation, and for measurements, and of small semiconductor lasers in physical research, electronic computers, is also discussed. Future aspects of laser applications in photon rockets, charting a topographic moon map, cybernetics, and in a laser rifle with a capacity of 10000 shots which may blind at a distance of 1500 meters, are projected.

G.G.

**N65-24836#** Army Missile Command, Huntsville, Ala.  
**REDSTONE SCIENTIFIC INFORMATION CENTER LASERS**  
Gus J. Caras 30 Apr. 1964 41 p refs  
(RSIC-195; AD-462245)

This state-of-the-art survey consists of a technical summary and a bibliography. The bibliography, which consists of 125 references and covers the period of 1 January 1963 to 31 December 1963, deals mostly with the subject of laser pumping. The summary reviews other topics of laser technology, and includes a description of the various types of lasers and their potential applications.

Author

**N65-24859** Texas Univ., Austin. Dept. of Electrical Engineering

**PROBLEMS AND PROGRESS IN CONTROL OF THERMONUCLEAR FUSION FOR ELECTRICAL POWER PRODUCTION**

Arwin A. Dougal / In Okla. State Univ. Proc. of the 2nd Ann. Energy Conversion and Storage Conf., Oct. 12-13, 1964 [1964] 8 p refs (See N65-24850 14-03) Available from Okla. State Univ. \$5.00

The basic principles of controlled thermonuclear fusion are summarized. Also, ion cyclotron resonances and waves in thermonuclear plasmas, and theta-pinch thermonuclear plasmas are discussed as representative of present day research. Further, the Faraday rotation method of infrared maser diagnostics is presented. Comparison of fusion approaches of the theta-pinch, pyrotron, stellarator, ion injection, and linear pinch methods are compared. Results show that the theta-pinch is an order of magnitude better than other approaches. Theta pinches are the best established means of producing plasmas with kilovolt energies, with at least short term stability, and with a plasma pressure comparable to that of the magnetic field. In the theta-pinch, the plasma is heated and contained by a longitudinal magnetic field produced by a high-current single turn coil.

E.E.B.

**N65-24968#** American Meteorological Society, Boston, Mass.  
**RELAXATION OSCILLATIONS IN THE EMISSION OF RUBY LASERS UNDER VARIOUS OPERATIONAL CONDITIONS**  
[RELAXATIONSSCHWINGUNGEN IN DER EMISSION OPTISCHER RUBIN-MASER UNTER VERSCHIEDENEN ARBEITSBEDINGUNGEN]

Karl Gürs Bedford, Mass., AFCRL, Jun. 1964 16 p refs Transl. into ENGLISH from Z. Naturforsch. (Tubingen), v. 18a, no. 4, 1963 p 510-515  
(Contract AF 19(628)-3880)  
(T-G-215; AD-458887)

The variations of the emission of ruby lasers with changes in resonator design and crystal temperature were investigated

experimentally and theoretically. A survey of the feasible emission behavior under different conditions is presented. For example, ruby, like certain other substances, can produce an emission which does not consist of pulses but is oscillation-free.

Author

**N65-25125#** Lockheed Missiles and Space Co., Palo Alto, Calif. Electronic Sciences Lab.

**PROGRESS REPORT, JANUARY-MARCH 1965**

W. F. Main [1965] 293 p refs  
(LMSC-6-75-65-10)

**CONTENTS:**

1. COHERENT LIGHT GENERATION W. Culshaw, C. H. Bazzill, J. A. Dahlquist, R. A. Early, L. B. Fowles et al 14 p refs (See N65-25126 14-16)
2. ATOMIC PHYSICS: RAMSAUER SCATTERING D. E. Golden, H. W. Bandel, and H. Nakano 10 p refs (See N65-25127 14-23)
3. ION PHYSICS: INTERACTIONS OF IONS, ATOMS, AND SURFACES R. N. Varney, R. B. Johansson, and G. A. Sinnott 1 p
4. IONIZATION COEFFICIENTS IN HYDROGEN L. H. Fisher, D. E. Golden, and H. Nakano 8 p (See N65-25128 14-24)
5. PROPAGATION OF ELECTROMAGNETIC WAVES THROUGH PLASMAS R. M. Hill, G. F. Herrmann, S. J. Tetenbaum, and R. D. Whitmer 15 p refs (See N65-25129 14-25)
6. PRODUCTION AND STUDY OF A CESIUM PLASMA IN THERMODYNAMIC EQUILIBRIUM L. H. Fisher, D. E. Golden, and R. Johansson 10 p refs (See N65-25130 14-25)
7. INITIATION OF ARC DISCHARGES IN THE NEIGHBORHOOD OF PLASMAS R. N. Varney and G. A. Sinnott 1 p
8. ELECTRONIC STRUCTURE OF CRYSTALS F. Herman, R. L. Kortum, C. D. Kuglin, and R. A. Short 4 p refs (See N65-25131 14-26)
9. COLLECTIVE EXCITATIONS IN SOLIDS M. E. Browne and T. O. Woodruff 2 p refs
10. SEMICONDUCTOR PHYSICS K. F. Cuff, M. R. Ellett, R. B. Horst, E. R. Washwell, and L. R. Williams 3 p refs
11. SEMICONDUCTOR LASERS K. F. Cuff, F. A. Junga, E. R. Washwell, and L. R. Williams 2 p refs
12. SPECTROSCOPY OF SOLIDS K. A. Wickersheim and E. Anderson 2 p
13. ELECTRON SPIN ECHO RESONANCE D. E. Kaplan 1 p
14. RELAXATION TIME AND INTERACTION WITH ULTRASONICS OF RARE EARTH IONS IN  $\text{CaF}_2$  W. Dobrov 6 p refs (See N65-25132 14-26)
15. RESONANCE IN ORDERED SPIN SYSTEMS P. E. Wigen 4 p refs
16. SHEAR AND LONGITUDINAL MAGNETOELASTIC WAVES IN TRANSVERSELY MAGNETIZED RODS R. L. Comstock and P. E. Wigen 4 p refs (See N65-25133 14-26)
17. MAGNETOELASTIC WAVE PARAMETRIC INSTABILITY ANALYSES R. L. Comstock and E. R. Hansen 3 p refs (See N65-25134 14-26)
18. WAVE NUMBER DEPENDENCE OF SPIN WAVE RELAXATION IN YTTRIUM IRON GARNET R. L. Comstock 3 p refs
19. SPATIAL VARIATION OF THE MAGNETIZATION ACROSS A FERROMAGNETIC THIN FILM IN THE BETHE-PEIERLS-WEISS APPROXIMATION J. J. Pearson 4 p
20. MAGNETIC MATERIALS D. Wickham 1 p
21. FERROELECTRICS R. M. Hill, S. K. Ichiki, and J. G. Little 6 p refs (See N65-25135 14-26)
22. SUPERCONDUCTIVITY N. Kusnezov 3 p
23. THEORETICAL INVESTIGATION OF FORCES BETWEEN DIPOLE ARRAYS N. Kusnezov 17 p (See N65-25136 14-23)

24. EXPERIMENTAL INVESTIGATION OF FORCES IN MAGNETIC DIPOLE ARRAYS S. R. Hawkins and J. H. Harshman 7 p ref (See N65-25137 14-23)
25. HIGH-FREQUENCY FERRIMAGNETIC PRESSURE TRANSDUCER F. F. Stucki 3 p refs
26. THIN MAGNETIC FILM COMPONENTS P. S. Castro and F. F. Stucki 3 p
27. OXIDE SEMICONDUCTORS R. A. Quinn, C. L. Fiedler, W. M. Lilker, H. R. Kaiser, and R. B. Horst 3 p
28. OPTOELECTRONIC COMPONENTS W. D. Fuller, C. R. Arnold, P. S. Castro, K. R. Morsette, and D. A. Vance 3 p
29. MICROELECTRONICS R. A. Quinn, C. L. Fiedler, H. R. Kaiser, W. M. Lilker, B. Papara, and S. Zurman 3 p refs
30. RELAXATION PROCESSES IN VISCOELASTIC LIQUIDS G. C. Knollman, A. S. Hamamoto, D. O. Miles, and G. C. Norstrom 8 p refs (See N65-25138 14-06)
31. RELAXATION SPECTROSCOPY FOR THE LIQUID STATE G. C. Knollman, A. S. Hamamoto, D. O. Miles, and G. C. Norstrom 8 p refs (See N65-25139 14-06)
32. WAVE PROPAGATION IN RANDOMLY INHOMOGENEOUS MEDIA G. C. Knollman and J. J. Hartog 7 p refs (See N65-25140 14-07)
33. IMAGE FORMATION IN A TURBID UNDERWATER ENVIRONMENT A. E. Brown, P. S. Green, and G. C. Norstrom 2 p
34. ANOMALOUS PROPAGATION AND SIGNAL CORRELATION G. C. Knollman, J. J. Downing, J. J. Hartog, and J. K. Parks 2 p refs
35. LIBRARY SYSTEMS RESEARCH R. B. Whiteley, R. I. Tanaka, D. L. Drew, O. Firschein, M. A. Fischler, and R. K. Summitt 2 p
36. LIBRARY-ADA REFERENCE RETRIEVAL D. L. Drew, D. B. J. Bridges, O. Firschein, E. E. Graziano, C. D. Satterfield, M. R. Stark, and R. K. Summitt 2 p
37. MACHINE ORGANIZATION RESEARCH M. A. Fischler and R. D. Merrill 4 p
38. FACT RETRIEVAL O. Firschein, K. R. Gielow, R. K. Summitt, and G. T. Uber 2 p
39. AUTOMATIC INDEXING: AN EXPERIMENTAL COMPUTER PROGRAM H. R. Jascke, L. L. Earl, and D. Smith 1 p
40. A SYNTACTIC-STATISTICAL METHOD FOR AUTOMATIC INDEXING L. L. Earl 10 p refs
41. RUSSIAN-ENGLISH INDEXING AND RETRIEVAL H. R. Robison 4 p
42. OPTICAL CORRELATION OF INFORMATION F. F. Fulton, Jr., D. G. Peterson, and W. G. Weis 4 p
43. RESOLUTION IMPROVEMENT OF AN OPTICAL SYSTEM BY USING ROTATING RECTANGULAR APERTURES H. P. Greinel 10 p refs (See N65-25141 14-14)
44. THE XPOP PROGRAMMING SYSTEM PROJECT M. I. Halpern, W. H. Mead, and M. R. Stark 4 p refs
45. INTERVAL ARITHMETIC IN MATRIX COMPUTATIONS E. R. Hansen and R. Smith 2 p refs
46. MAGIC (MAGNIFICENT ALGORITHM GENERATOR OF INDETERMINATE CAPABILITY) K. R. Gielow and G. T. Uber 6 p
47. SEQUENTIAL MACHINE SYNTHESIS A. J. Nichols, III 2 p ref
48. BARBERPOLE OPTICAL CORRELATOR FOR SONAR SIGNALS J. K. Parks 9 p refs
49. AUDITORY DATA PROCESSING A. E. Brown, J. J. Downing, and G. C. Norstrom 7 p refs
50. MICROFILM-VIDEO STORAGE TUBE DISPLAY SYSTEM W. Y. Dere, W. G. Eppler, and N. S. Szabo 2 p
51. LMSC EXPERIMENTAL X-RAY FILM READER N. S. Szabo, W. G. Eppler, and G. J. Spesock 3 p
52. INTERNAL LASER MODULATION D. G. Peterson and A. Yariv 5 p refs
53. STUDIES OF DELAY-LOCK TRACKING FOR THE ARD SYSTEM R. B. Ward and R. A. Dye 6 p ref
54. SPECIAL PURPOSE RADAR ALTIMETER H. V.

Hance, W. J. Burgess, W. J. Gill, and R. L. Rutter 4 p ref

55. COMMUNICATION TECHNIQUES F. F. Fulton, W. J. Burgess, W. J. Gill, H. S. Tomlin, and W. G. Weis 10 p ref

56. LIGHT DIFFRACTION BY ULTRASONIC WAVES H. V. Hance and J. K. Parks 7 p refs (See N65-25142 14-23)

**N65-25126** Lockheed Missiles and Space Co., Palo Alto, Calif. Electronic Sciences Lab.

# **COHERENT LIGHT GENERATION**

W. Culshaw, C. H. Bazzill, J. A. Dahlquist, R. A. Early, L. B. Fowles et al *In its Progr. Rept.*, Jan.-Mar. 1965 [1965] 14 p refs (See N65-25125 14-34)

Progress on planar-type gas, confocal-type, and solid state lasers is reported. A short He-Ne laser, with a reflector spacing of 21.25 cm and operating at 1.153 microns, was constructed. This reflector spacing gives a frequency separation of 706 Mc/sec between axial modes and assures single-mode operation under most conditions. The laser tube has a bore of 3 mm and a discharge of 11.5 cm long, excited by an rf-source at 52.5 Mc/sec. A solenoid of 3.2-cm diameter and 14.6 cm long was placed around the laser tube for applying axial magnetic fields in the study of coherence effects due to small axial magnetic fields. Also, a pulsed gas discharge laser was made and operated simultaneously on six lines of the Argon II spectrum. The tube was 130 cm long with a bore of 3 cm and Brewster windows. The cavity length was 140 cm and the reflectors have optimum reflectivity at 4500 and 5300 Å. Further, a system for the study of magnetic fields in continuously operating solid state lasers was assembled. This laser uses N<sub>2</sub> or supercooled liquid O<sub>2</sub> as a coolant and a 1000-W tungsten lamp as an optical pumping source. An yttrium-aluminum-garnet laser rod doped with Nd<sup>3+</sup> was also operated at room temperature. E. E. B.

**N65-25191#** Ohio State Univ. Research Foundation, Columbus. Antenna Lab.

# **PROPAGATION OF INTENSE LASER RADIATION Final Engineering Report, 1 Jan. 1963-31 Dec. 1964**

15 Apr. 1965 30 p refs *Its Rept.*-1579-20

(Contract AF 33(657)-10824)

(AFAL-TR-65-83; AD-61627)

Research directed towards investigating factors limiting the transfer of laser radiation through real media is summarized. Laser-induced gaseous breakdown is discussed, and some measurements on the frequency dependence of this phenomenon are given. Parametric interactions of radiation and matter are described, and a new type of Brillouin scattering is observed. The coherence characteristics of spiking multimode lasers are discussed, and the influence of the measuring techniques on the measured coherence properties is examined. Atmospheric resonance absorption is reviewed, and results at specific laser frequencies are given. Related effort in laboratory source and instrumentation development is described. Author

**N65-25399#** Massachusetts Univ., Amherst. Polymer Research Inst.

# **A TECHNIQUE FOR THE STUDY OF SPHERULITE DEFORMATION LIGHT SCATTERING MOVIES**

P. F. Erhardt and R. S. Stein 1 Dec. 1964 3 p ref

(Contract Nonr-3357(01))

(ONR-TR-77; AD-612489)

The use of a continuous wave gas laser, and of a high speed motion picture camera as the detector to obtain a nearly continuous set of light scattering photographs from a single polymer sample of polyethylene, is described. The stretching direction of the medium density polyethylene was along the long axis of the film strip and the polarization directions were perpendicular and parallel to the direction of stretch. Good

scattering pictures were obtained at camera speeds as high as 5400 frames per second and the change in  $H_v$  scattering patterns on the stretched sample is illustrated. G.G

**N65-25537#** Lincoln Lab., Mass. Inst. of Tech., Cambridge.  
**SOLID STATE RESEARCH, 1 OCTOBER-31 DECEMBER 1964**

23 Mar. 1965 75 p refs  
(Contract AF 19(628)-500)  
(ESD-TDR-65-31; AD-613961)

Topics covered are *Solid State Device Research, Laser Research, Materials Research, Band Structure and Spectroscopy of Solids, and Magnetism and Resonance.* Author

**N65-25580#** Air Force Systems Command, Wright-Patterson AFB, Ohio Air Force Avionics Lab.  
**PRECISION RANGE-GATED IMAGING TECHNIQUES Technical Report, Mar.-Sep. 1964**  
Don B. Neumann Jan. 1965 22 p  
(AFAL-TR-64-278; AD-612790)

By properly delaying the 50-nanosecond shutter of an image-converter camera with respect to a transmitted 60-nanosecond illuminating pulse from a Q-switched ruby laser, the image formed may be limited to only those objects located in a certain range interval. Using this technique, the visibility through atmospheric scattering mediums, such as snow, may be greatly increased. In addition, the use of the technique enables range information to be added to an image, such as the elevation contours in an aerial photograph. Author

**N65-25599\*#** National Aeronautics and Space Administration, Washington, D. C.  
**LASERS AND MASERS: A CONTINUING BIBLIOGRAPHY, JANUARY 1962-FEBRUARY 1965**  
May 1965 283 p refs  
(NASA-SP-7009) CFSTI: HC \$2.50/MF \$1.50 CSCL 20E

An annotated bibliography is presented which includes studies on the research and development of lasers and masers, their application to ranging and communications systems, astronomy and optics, and metalworking. Also included are studies on their physical and electronic properties, functions, and performance. R.N.A.

**N65-25688#** American Optical Co., Southbridge, Mass. Research Div.  
**NEODYMIUM LASER GLASS IMPROVEMENT PROGRAM Technical Summary Report, 30 Jun. 1964-1 Jan. 1965**  
Richard F. Woodcock Apr. 1965 17 p refs  
(Contract Nonr-3835(00); ARPA Order 306-64; Proj. Defender)  
(TSR-5; AD-613963)

The birefringence effects of various oxides used in making glass were studied to determine their feasibility in developing other zero stress-birefringence glasses to be used for neodymium laser glass. A series of glass compositions of both Pockels type and non-Pockels type glasses were examined for their thermal coefficient of the index of refraction, their coefficient of thermal expansion, and their stress-optical coefficient. The observed data are being analyzed. It was felt, that an athermalized laser system can be produced by counterbalancing the index of refraction changes produced by stress with index changes produced by temperature directly. G.G.

**N65-25734#** General Electric Co., Syracuse, N. Y. Heavy Military Electronics Dept.  
**AROMATIC ORGANIC LASER DEVELOPMENT Final Report, 1 Apr. 1963-31 Mar. 1965**  
D. L. Stockman [1965] 77 p refs  
(Contract Nonr-4135(00); ARPA Order 306-62; Proj. Defender)  
(AD-613295)

A theoretical analysis and experimental work is reported on the development of a laser to produce coherent stimulated emission in the blue-green region in a purely organic dopant and host system. The theoretical analysis indicates that short lived four-level fluorescent compounds are the most suitable materials for this purpose. A total of four fluorescent compounds were found with the appropriate spectroscopic characteristics. The principal experimental efforts have included the development of a suitable host material in which the absorbing and scattering losses are kept to a minimum and an optical pump system capable of efficiently producing several megawatts of absorbable peak power in a short time. An optically isotropic polymer was developed whose properties appear to be suitable as a host material for the fluorescent species. Two optical pumping systems were used: (1) a modified xenon lamp, and (2) an argon theta-pinch lamp. Both of these systems were used to pump the samples. Some gain was observed in a liquid containing perylene as the active compound. This gain was observed at 4710 Å and probably due to preoscillation "super-radiance" Gain in the fluorescent compounds contained in the polymer rods was not observed. N.E.A.

**N65-25782#** Army Frankford Arsenal, Philadelphia, Pa. Research and Development Directorate  
**EXPERIMENTAL STUDY OF NEODYMIUM DOPED GLASS LASER**  
Alexander J. Casella Feb. 1965 58 p refs  
(R-1748; AD-612885)

The effect of doping level and diameter of neodymium glass rods and reflectivity of the output mirror on the threshold energy and output energy of the laser and discussed. Data are presented on the energy output of glass rods having diameters of 0.25 in., 0.393 in., and 0.5 in. and doping levels of 1, 3, and 6% neodymium. In most cases, an output mirror reflectivity of 62% gave the highest energy output. Maximum output was obtained with the 1% doping, 0.5 in. diameter rod, using a 62% reflecting mirror. Due to pitting of the rods, the data were generally inconsistent and nonreproducible. Author

**N65-25851#** Westinghouse Electric Corp., Baltimore, Md. Aerospace Div.  
**DEVELOPMENT OF MILLIMETER AND SUBMILLIMETER MASER DEVICES Interim Technical Report No. 6, 1 Nov. 1964-28 Feb. 1965**  
W. E. Hughes, C. R. Kremenek, and W. E. Richards [1965] 44 p refs  
(Contract AF 33(657)-10472)  
(Rept.-490F; AD-612489)

During this reporting period, the major effort has been directed toward the operation of masers in the absence of an applied external magnetic field. The effort has been divided into two specific areas; i.e., 9.3 gc and 81 gc. Zero field masers have been successfully operated in both areas and the description of their operation comprises the bulk of this report. Each maser is described in detail and the conclusions drawn from experiments are given. Author

**N65-25890#** PEK Labs., Inc., Sunnyvale, Calif.  
**LASER FLASH LAMP Semiannual Technical Summary Report, 30 Nov. 1963-1 Jun. 1964**

C. H. Keller, J. P. Moffatt, and G. O. Harding [1964] 19 p refs (Contract Nonr-4122(00); Proj. Defender) (AD-613346)

An optimization study is presented on the development of flash lamps for pumping laser rods. Two approaches are being pursued, one uses an opacity measurement to determine the advantages of doping the spectral output to select wavelengths within the narrow pumping band, and the other is a brute force series of trials in which lamps of sturdier than usual structure are tested to their destructive limit. A variety of flash tube forms are described. One form considered because of its accuracy, consists of a single tube with parallel flat sides from angles 0° to 60° and a metal aperture for light selection. A Claesson-type lamp is described and the results of its destructive testing are tabulated. R.N.A.

**N65-25901#** Eastman Kodak Co., Rochester, N. Y.  
**LASER MATERIAL STUDY Final Report, 1 Jul. 1962-30 Jun. 1964**  
Paul Maurer 22 Feb. 1965 25 p Submitted for Publication (Contract Nonr-3834(00)) (AD-612459)

Three types of neodymium doped laser glass—a lanthanum-barium borate, a lithium-sodium silicate, and a barium crown—are compared because of their widely differing fluorescence characteristics. The glasses were fabricated into rods, 1.27 cm diameter and 30.5 cm long. Fluorescence decay data, optical quality data, output-input data, and output field patterns are included. The fluorescence characteristics were less significant than optical quality as a determinant in laser behavior. Author

**N65-25966#** General Electric Co., Syracuse, N. Y. Electronics Lab.  
**AROMATIC ORGANIC LASER DEVELOPMENT Quarterly Report**  
David L. Stockman [1965] 5 p  
(Contract Nonr-4135(00); ARPA Order 306-62) (QR-7; AD-612932)

Progress towards the development of a laser employing fluorescent organic compounds is reported. A continuum peaking in the range of 3500 to 4000 Å was observed in the argon-theta-pinch lamp spectral measurements. The irradiance of the lamp continuum at its peak corresponds in brightness to about 8000° to 10000° K blackbody. If the continuum were due to blackbody radiation, an 8000° K source would peak at 3650 Å and a 10000° K source at 2900 Å. Thus, it is not a clear cut case that the continuum is due to black-body radiation. Bremsstrahlung and recombination radiation are obvious possibilities. Also, on top of the continuum were a multitude of very narrow, very intense lines corresponding to atomic argon and to at least the first two ionized states of argon. The maximum output of the lines and the continuum was between 3000 Å and 4500 Å, making the lamp quite suitable for pumping perylene. A rough estimate of the radiating efficiency was that 1% to 10% of the electrical power is radiated as continuum between 2700 Å and 5700 Å. E.E.B.

**N65-26015#** Brown Engineering Co., Inc., Huntsville, Ala. Research Labs.  
**FEASIBILITY STUDY OF A LASER FLOWMETER FOR LOCAL VELOCITY MEASUREMENTS IN GAS FLOW FIELDS**  
J. W. Foreman, Jr., E. W. George, and R. D. Lewis May 1965 24 p refs (R-149)

The Doppler shift in laser light scattered from smoke particles in a moving gas has been detected by optical heterodyne techniques, thereby verifying the feasibility of a laser Doppler flowmeter for measurement of local velocities in contaminated gas flow fields. Author

**N65-26127#** Brown Engineering Co., Inc., Huntsville, Ala. Research Labs.

**RAYLEIGH SCATTERING OF COHERENT LIGHT BY GASES**  
H. J. Watson, R. R. Mitchell, and J. R. Thornton Feb. 1965 40 p refs (R-135)

This experiment is designed to study Rayleigh scattering using laser light (6943Å) and to determine if the laser can be used as a diagnostic tool to determine scattering center density. The scattered light intensity from argon, oxygen, nitrogen and air has been observed. The angular dependence of scattered light intensity for different polarizations of the incident laser beam has been observed for argon gas, and a linear relationship between scattered intensity and pressure exists for all gases studied. The relative differential scattering cross sections for argon, nitrogen and oxygen has been determined and compared with different theoretical predictions. The combined results indicate that it is possible to determine densities within reasonable accuracy between one atmosphere and ten microns under the conditions of this experimental arrangement. The problems of observations and the limitation of this technique are discussed. Author

**N65-26401\*#** Sylvania Electric Products, Inc., Waltham, Mass. Applied Research Lab.  
**DEVELOPMENT OF AN OPTICAL SUPERHETERODYNE RECEIVER Summary Report, Mar. 1964-Mar. 1965**  
R. F. Lucy, ed. 17 May 1965 97 p refs (Contract NAS8-11588) (NASA-CR-63393; F-4065-1) CFSTI: HC \$3.00/MF \$0.75 CSDL 09F

This report describes the technical investigations performed during the design and development of an optical superheterodyne receiver. The net result of this effort has produced a tested design for a field model system. The investigations described include the testing of an experimental over a 6000 foot path, theoptics, photomixing, doppler frequency tracking, optical frequency translation techniques and spatial alignment of the received signal and local oscillator. Author

**N65-26426#** Illinois Univ., Urbana. Electrical Engineering Research Lab.  
**STUDIES IN QUANTUM AND SOLID STATE ELECTRONICS Final Report**  
Paul D. Coleman et al. 1 Feb. 1965 11 p refs (Grant AF-AFOSR-272-63)

(1) Optical pumping in dark ruby: Attempts were made to get maser action in the submillimeter region by incoherent optical pumping in a solid. The absorption of thermal noise power in a microwave resonator by an appropriate crystal therein is regarded as capable of changing the fluorescent intensity in the crystal. The terminal level of the fluorescent line must be one of the levels between which there is microwave absorption. (2) Harmonic generation in HCN by multiple quantum conversion: a traveling wave interaction in a 2.5-meter section of RG 96/U waveguide containing HCN gas produced a peak power at 104.1 GC of 1.8 watts. (3) Submillimeter-wave spectroscopy: A submillimeter wave monochromator was designed and constructed that is capable of covering the spectral region from 100 microns out to about 2.5 mm in wavelength. (4) Mixing of laser light in a bulk photoconductor, beat notes of 3 GC were detected on production by Fabry-Perot mode frequencies of a laser when mixed in a bulk photoconductor and compared with previous results. TAB

**N65-26625#** Lockheed Missiles and Space Co., Sunnyvale, Calif.  
**SOME LASER-SYSTEMS CONSIDERATIONS**  
G. M. Kerbyson 24 Jan. 1963 28 p (LMSC-704217)



The characteristics and limitations of lasers for applications in military and space systems are discussed. The state of the art and projections of future developments in lasers systems are also considered, and the feasibility of, and problem areas for, several general laser systems are indicated. Various types of lasers discussed include crystal, glass, gas, liquid, semiconductor, and quasi lasers. Transmission medium; pointing and tracking requirements; power, weight, and volume requirements; and information transmission are reviewed with respect to systems applications. Other laser topics discussed are laser noise, optical-radar, beam guidance, illumination, weapons, undersea, communications, attitude control, power-energy transmission, and data conversion applications. L.S.

**N65-26678** Varian Associates, Beverly, Mass.  
**TIME AND FREQUENCY COMPARISONS WITH THE ATOMIC HYDROGEN MASER**

H. E. Peters, J. Vanier, and R. F. C. Vessot *In Soc. Suisse de Chronometrie Intern. Conf. on Chronometry, Vol. 1 [1964] p 297-304 refs* Sponsored by ONR (See N65-26657 16-14)

The fractional relative stability data taken over several months have shown the masers to be stable to well within  $2 \times 10^{-12}$ . R.M.S. values taken over intervals of hours and tens of seconds give fractional relative stability figures of  $4.8 \times 10^{-13}$  and  $8.7 \times 10^{-14}$ , respectively. Drift effects of the order of  $1 \times 10^{-12}$  are due to thermal effects of the cavity resonator. Short term statistical fluctuations are predictable from the noise characteristics of the receiver. Cavity tuning by means of the spin exchange relaxation processes completely cancel, in the oscillating maser, the effect of pressure shift in frequency. Maser frequency resettability using this method has been found to be better than  $5 \times 10^{-13}$ . Improvements in maser design resulting in longer lifetime and smaller size have resulted in the construction of a production prototype occupying 4 square feet of floor space and 6 feet in height. Lifetime, limited by the pumps, should be well in excess of two years. Details of improvements in thermal control circuitry are described. Measurements of time comparison on the masers via Loran "C" are outlined. Author

**N65-26679** Physikalisch-Technische Bundesanstalt, Brunswick (West Germany).

**ON THE FOCUSING OF ATOMIC BEAMS FOR HYDROGEN MASERS [ZUR FOKUSSIERUNG VON WASSERSTOFFATOMSTRAHLEN FÜR WASSERSTOFFMASER]**

Gerhard Becker and Bernd Fischer *In Soc. Suisse de Chronometrie Intern. Conf. on Chronometry, Vol. 1 [1964] p 305-316 refs* In GERMAN; FRENCH and ENGLISH summaries (See N65-26657 16-14)

The distribution of the density of the beam at the site of the detector has been calculated under the assumption of a point source of hydrogen atoms and of a relatively short magnetic deflection system (which can be idealized like in the optical case by a thin lens). It is taken account also of the velocity distribution of the atoms in the beam. The results are represented by approximation formulas. They suggest certain design principles for optimising the separation of the states in the deflection system. Moreover the possibility to use annular magnetic fields instead of six-pole fields for the separation and focusing has been analysed. Author

**N65-26681** Hewlett-Packard Co., Palo Alto, Calif.  
**A MODERN SOLID-STATE PORTABLE CESIUM-BEAM STANDARD**

A. S. Bagley and L. S. Cutler *In Soc. Suisse de Chronometrie Intern. Conf. on Chronometry, Vol. 1 [1964] p 333-352 refs* (See N65-26657 16-14)

A compact, solid-state cesium beam frequency standard will be described. The circuitry associated with the short beam tube is designed to be highly reliable. Size and power consumption have been kept to a minimum, and the equipment is designed to work from a 26 V d.c. power source so it may be used on a standby battery source for clock applications. The frequency synthesizer is in the main loop. The design is such that the time scale in which the output frequencies of 5 mc, 1 mc, and 0.1 mc are expressed is easily changed by replacement of a single component. Particular effort was given to the design of the synthesizer to keep the amplitude of spurious frequencies sufficiently low. Logic circuitry is provided so that proper operation is indicated by a combination of lights. In addition, metering of various circuits is provided. Absolute accuracy is  $\pm 6 \times 10^{-11}$ , making the standard useful as a precision clock. Author

**N65-26684** Czechoslovak Academy of Sciences, Prague.  
**RESULTS OF EXPERIMENT WITH 2 AMMONIA MASERS [VERSUCHSRESULTATE MIT ZWEI AMMONIAKMASERN]**  
 Uiktor Trkal *In Soc. Suisse de Chronometrie Intern. Conf. on Chronometry, Vol. 1 [1964] p 365-373 refs* In GERMAN; ENGLISH and FRENCH summaries (See N65-26657 16-14)

This paper discusses the methods of tuning the cavity by modulation of the ammonia pressure and by Zeeman modulation. The influence of the design parameters of the apparatus will also be discussed. Author

**N65-26685** Besancon Univ. (France). Laboratoire de l'Horloge Atomique.

**THE USE OF THE ZEEMAN EFFECT ON THE 3.3-LINE OF  $N^{14}H_3$  [APPLICATION DE L'EFFET ZEEMAN A LA RAIE 3-3 DE  $N^{14}H_3$ ]**

M. Olivier *In Soc. Suisse de Chronometrie Intern. Conf. on Chronometry, Vol. 1 [1964] p 375-382 refs* In FRENCH; ENGLISH and GERMAN summaries (See N65-26657 16-14)

Zeeman modulation of an ammonia Maser used as a frequency standard gives a criterion for setting the frequency of the cavity. The hyperfine structure of the 3.3-line gives a complex dependence of the frequency of oscillation on the magnetic field. We have studied this effect proving that nevertheless the Zeeman effect can be used as a tuning criterion for a secondary frequency standard. A precision of  $10^{-11}$  is achieved for the measurements and the stability of the frequency depends only on the resettability of the experimental parameters. Author

**N65-26765#** Naval Ordnance Lab., Corona, Calif.  
**FOUNDATIONAL RESEARCH PROJECTS Quarterly Report, Oct.-Dec. 1964**

C. J. Humphreys 1 Mar. 1965 133 p refs  
 (NAVWEPS-8226; AD-613340)

**CONTENTS:**

1. OBSERVATION OF MAGNETIC DOMAINS BY MEANS OF HeNe LASER LIGHT J. L. Tomlinson p 1-3 refs (See N65-26766 16-16)

2. SYNTHESIS OF A CYCLIC HEXAPHENYLDICHLOROPHOSPHONITRILE TETAMER AND ITS REACTION WITH DIOLS D. L. Herring and C. M. Douglas p 5-15 refs (See N65-26767 16-06)

3. COUPLING REACTIONS BETWEEN HEXAPHENYLDIAZIDOCYCLOPHOSPHONITRILE AND SELECTED BISTERTIARY PHOSPHINES A. J. Bilbo and C. M. Sharts p 16-43 refs (See N65-26768 16-06)

4. PARTIALLY COHERENT LIGHT FROM INCOHERENT SOURCES T. Hadeishi p 45-51 refs (See N65-26769 16-16)

5. COVARIANT FORM OF THE GYRATION VECTOR OF AN INSULATING CRYSTAL FOR FREQUENCIES CLOSE TO THE GAP FREQUENCY A. Nedoluha p 53-69 refs (See N65-26770 16-26)

6. IMPROVED TECHNIQUE FOR THE MEASUREMENT OF THE ROTATION OF THE PLANE OF POLARIZATION C. J. Gabriel, V. A. Patton, and H. Piller p 69-85 refs (See N65-26771 16-26)

7. PLASMA AND SPIN RESONANCE IN SEMICONDUCTORS, MEASURED WITH THE VARIAN V-4500 EPR SPECTROMETER G. Zaeschmar p 85-94 refs (See N65-26772 16-26)

8. FLUORESCENCE SPECTRUM OF  $\text{Pr}^{3+}$  IN  $\text{LaF}_3$  H. E. Rast and R. A. Buchanan p 95-113 refs (See N65-26773 16-26)

9. INTERMEDIATE COUPLING ENERGY LEVELS FOR  $\text{Nd}^{3+}$  ( $4f^3$ ) IN  $\text{LaF}_3$  H. H. Caspers, H. E. Rast, and R. A. Buchanan p 114-133 refs (See N65-26774 16-26)

**N65-26766** Naval Ordnance Lab., Corona, Calif. Electricity and Magnetism Div.

**OBSERVATION OF MAGNETIC DOMAINS BY MEANS OF  $\text{HeNe}$  LASER LIGHT**

J. L. Tomlinson *In its* Foundational Res. Proj. 1 Mar. 1965 p 1-3 refs (See N65-26765 16-26)

A helium-neon gas laser was used as the light source to study the Kerr magneto-optical effect of a ferromagnetic thin film consisting of 80% Ni and 20% Fe. The magneto-optic effect could be seen through a microscope as a red spot when the film was magnetized in the direction of maximum intensity of the magneto-optic image. Rotation of a permanent magnet near the film changed the direction of the magnetization and caused the red spot to disappear. Attempts to observe a change in intensity with a photomultiplier were not successful. G.G.

**N65-26930** Hoffman Electronics Corp., Santa Barbara, Calif. Science Center.

**DIRECT CURRENT STIMULATED ELECTROLUMINESCENCE Final Report**

30 Oct. 1964 12 p  
(Contract N123(62738)35519A(X))  
(AD-461889)

Recombination in p-n junctions in gallium arsenide diodes was studied to develop injection luminescent radiation sources with desirable operating characteristics. Work was done on improving the internal quantum efficiency of spontaneous radiation in the diode, in the belief that a reduction in the percentage of nonradiative recombinations at room temperature may be possible. Junctions were fabricated using diffusion of zinc into n-type gallium arsenide, and by epitaxial growth from gallium and tin melts. The melts were doped by the addition of small amounts of metallic zinc, tellurium, or selenium. Laser threshold current versus temperature were plotted for both the diffused junctions and the solution grown junctions. It appears that the probability of spontaneous radiative recombination is greater in the solution grown epitaxial diodes, especially at higher temperatures. In another experiment, measurements on diodes from over 50 junctions grown epitaxially from solution in either gallium or tin indicate that donors in the crystal, from column V of the periodic chart, are about equally effective in producing radiative recombination. This is compared to silicon in which, at concentrations of up to about  $10^{17} \text{ cm}^{-3}$ , the radiative recombination efficiency is about the same as column V donors, but increases by a factor of three at higher concentrations. L.S.

**N65-27084#** Barkley and Dexter Labs., Inc., Fitchburg, Mass. **RESEARCH TOWARD DEVELOPMENT OF GEOMETRIC DISTANCE AND ANGLE MEASUREMENT SYSTEMS Final Report**

Raymond B. Wilson, Jr. Jan. 1965 102 p refs  
(Contract AF 19(628)-3895)  
(AFCRL-65-196; AD-615912)

This report documents work done under Contract AF19-(628)-3895 and includes gas laser, ruby laser, shutter timing and photomultiplier tube studies and investigations. The two areas reported on in laser work are a feasibility study of a gas laser in geodetic leveling, which terminates in suggestions for a gas laser oriented leveling system, and a medium power Q-switched laser capable of ranging experiments. The Q-switched laser was constructed under the contract. Research support was given to AFCRL in the shutter and photomultiplier tube studies. A portable laser power supply, timing system for a PC 1000 external shutter, and 5 channel current amplifier were constructed under this contract, and a description of each is given. Author

**N65-27088#** Technical Research Group, Inc., Melville, N. Y. **THEORETICAL RESEARCH ON LASER OSCILLATION Final Report**

Morris C. Newstein, Stephen R. Barone, and Nicholas Solimene Bedford, Mass., AFCRL, May 1965 21 p refs

(Contract AF 19(604)-8817)  
(AFCRL-65-270; AD-615804)

Topics considered in six scientific reports prepared under the contract are: the theory of plane-parallel Fabry-Perot resonators, perturbed Fabry-Perot resonators, Fabry-Perot resonators at small Fresnel numbers, thermal fields and spontaneous emission in open resonators and the quantum theory of optical coherence. Abstracts and summaries of these six reports are presented as well as an account of some preliminary results on a dynamical theory of laser oscillation. Author

**N65-27099#** Cornell Univ., Ithaca, N. Y. School of Electrical Engineering

**INVESTIGATION OF LINEAR BEAM AND NEW CONCEPTS OF MICROWAVE POWER GENERATION**

G. C. Dalman and L. Mac Kenzie Griffiss AFB, N. Y., RADC, Apr. 1965 58 p refs  
(Contract AF 30(602)-3243)  
(RADC-TR-65-22; AD-615756)

The interaction of magnetically focused electron beams with electromagnetic circuits, basic electromagnetic interaction circuits, electron beam phenomena, electron-beam plasma amplifier, and laser-stimulated electron emission are discussed. The feasibility of using biased electron beams to control phase shift in linear beam tubes is demonstrated. The research on magnetically focused electron beams included the results of experiments conducted on immersed-flow electron beams, and the effects of axially varying magnetic fields on beam properties. Experiments showing the presence of strong microwave interactions in a beam-generated plasma are also described. Basic probe measurements of electron densities and effective electron temperatures were made on an argon plasma identical to that used for the beam-plasma amplifier. Further, two applications of the laser-induced electron beam were considered: (1) the measurement of the beam-loading admittance; and (2) the active interaction in which a radio-frequency is propagated by the beam. E.E.B.

**N65-27203#** International Business Machines Corp., Yorktown Heights, N. Y. Thomas J. Watson Research Center **INJECTION LASER STUDY Seventh Quarterly Progress Report, 1 Dec. 1964-28 Feb. 1965**

K. Konnerth, F. F. Morehead, F. Stern, P. R. Wagner, and K. Weiser [1965] 104 p refs  
(Contract DA-36-039-AMC-02349(E))  
(Rept.-7: AD-615147)

Switching characteristics of P-P<sup>+</sup>-N negative resistance diodes are determined. The breakdown voltage and the sustaining voltage of the devices are in good agreement with theory, but the switching times are somewhat longer than predicted by theory. Numerical procedures for solving the complex eigenvalue equation are described in detail. A method for finding the number of square integrable solutions with continuous derivatives which fall in any region of the complex eigenvalue plane is also described. The procedures found solutions that were overlooked previously. A numerical example is given. The emission of yellow electroluminescence at 77° K. by electron injection from an indium contact into an insulating region on the surface of phosphorus-doped ZnTe, was observed in a 30-micron-thick layer adjacent to the contact. The emission had a quantum efficiency of  $10^{-4}$ . No visible emission was obtained at room temperature. A simple theory of the response of semiconductor absorbers and amplifiers to high intensity monochromatic light is in qualitative agreement with experiment. L.S.

**N65-27234** Joint Publications Research Service, Washington, D. C.

# STATISTICAL CHARACTERISTICS OF THE AUTOMODULATION OF THE SOLID LASER RADIATION

V. I. Bespalov and A. V. Gaponov *In its Izv. VUZov: Radiophys.*, Vol. VIII, No. 1, 1965 24 Jun. 1965 p 85-99 refs (See N65-27225 16-34) CFSTI: \$6.00

The influence of spontaneous radiation on the behavior of a two-level system with different longitudinal and transverse relaxation times located within a one-mode resonator was studied. Results show that spontaneous radiation leads to a more rapid attenuation of modulation during the transient regime. Maximum power was found in the peaks of solid laser radiation, the magnitude of which was logarithmically dependent on the intensity of spontaneous radiation. Included is an analysis of equations used to establish laser oscillations without allowing for fluctuations, laser oscillations in the presence of spontaneous radiation, the distribution function of radiation intensity within the maximum of the first peak, and the influence of spontaneous radiation on the characteristics of consecutive peaks. S.C.W.

**N65-27236** Joint Publications Research Service, Washington, D. C.

# STEADY-STATE OSCILLATIONS OF LASERS WITH DISTRIBUTED LOSSES

L. A. Ostrovskiy and Ye. I. Yakubovich *In its Izv. VUZov: Radiophys.*, Vol. VIII, No. 1, 1965 24 Jun. 1965 p 114-123 refs (See N65-27225 16-34) CFSTI: \$6.00

Electromagnetic oscillations within a plane parallel layer containing two-level active molecules, where the axis-x is perpendicular to the boundaries of the layer, were studied. Energy losses stimulated by radiation across the layer's boundaries, and losses within the medium containing active molecules, are considered in the analysis. The frequency spectrum of steady-state nonlinear oscillations and the corresponding spatial distributions of amplitudes and phases were determined. It is shown that the presence of volume losses within thick layers leads to nonunique space distribution of the fields of a given frequency. S.C.W.

**N65-27252** Joint Publications Research Service, Washington, D. C.

# OBSERVATION OF MULTIBEAM GENERATION OF A HELIUM-NEON LASER

Yu. I. Zaytsev and D. P. Stepanov *In its Izv. VUZov: Radiophys.*, Vol. VIII, No. 1, 1965 24 Jun. 1965 p 265-268 refs (See N65-27225 16-34) CFSTI: \$6.00

Reported are results of several experiments with a helium-neon laser in which multibeam radiation with a wave length of 0.6328 microns was observed. Excitation was achieved by introducing into the resonator a laser generating heterogeneities either in the form of a flat plate with a wedge of optical or quartz glass at the Brewster angle to the beam of radiation, or opaque objects, as a segment of wire, perpendicular to the axis of the beam. Observed were single oscillational processes, partial oscillations, and four- and three-beam oscillations. The conditions of multibeam generation were stable with respect to dimensional changes of the resonator. Data are included on the wobbling of adjacent modes in straight beams and of corresponding modes in the radiation angular-type oscillations. S.C.W.

**N65-27253** Joint Publications Research Service, Washington, D. C.

# THE PARAMETER OF EXCITATION OF A BEAM-TYPE MASER

A. F. Krupnov and V. A. Skvortsov *In its Izv. VUZov: Radiophys.*, Vol. VIII, No. 1, 1965 24 Jun. 1965 p 269-274 refs (See N65-27225 16-34) CFSTI: \$6.00

Presented are results of an attempt to estimate the value of the maximum permissible parameter of excitation of beam-type maser generators, which focuses on determining quantitatively the influence of collisions in the beam. Examined is a parallel molecular flux impinging on a sorting system having optimum length and radius, in which half of the molecules are on upper levels and half are on lower levels. The dependence of the parameter of excitation on the size of the molecular flux and the length of the sorting system was determined. Results obtained are compared with data from an experiment with a formaldehyde molecular generator. S.C.W.

**N65-27555#** Defense Research Corp., Santa Barbara, Calif. INTERACTION OF HIGH INTENSITY RADIATION AND MATTER Final Report, Oct. 1964-Mar. 1965

Peter Redmond 1 Apr. 1965 4 p  
(Contract DA-31-124-ARO(D)-94)  
(AROD-4157-4; AD-614615)

Investigations on the refractive index of a relativistic plasma and the solution of the Schrodinger equation for a particle in a harmonic oscillator well in the presence of a uniform static magnetic field and a uniform time-dependent electric field are reported. When intense radiation is propagating through a plasma, there will be nonlinear effects produced by the  $\vec{v} \times \vec{B}$  term in the interaction. These effects can be treated exactly for suitably idealized models of the plasma. For many systems the unperturbed motion of the particles is well described by a harmonic oscillator. If the radiation is incident on such a system in the presence of a magnetic field, and if the radiation field is treated using the dipole approximation, then the problem reduces to the Schrodinger equation for a particle in a harmonic oscillator well in the presence of a uniform static magnetic field. E.E.B.

**N65-27581#** Hughes Aircraft Co., Culver City, Calif. Laser Development Dept.

# CONTINUOUSLY PULSED LASER DEVICE FOR SURVEILLANCE Second Quarterly Report, 1 Oct.-31 Dec. 1964

James H. Morse [1964] 19 p  
(Contract DA-28-043-AMC-00326(E))  
(Rept.-2: AD-614445)

This report describes experimental Nd:YAG laser heads using both tungsten lamps and xenon flashtubes for pump excitation. These preliminary experiments were directed to gain information for designing high repetition rate, Q switched laser. Final design of the device is being delayed pending the receipt of suitable Nd:YAG crystal. Author

**N65-27655#** RAND Corp., Santa Monica, Calif.  
**QUANTUM STATISTICAL DYNAMICS OF LASER AMPLIFIERS**

Dennis Holliday and A. E. Glassgold (New York Univ.) Apr. 1965 74 p refs  
 (Contract AF 49(638)-700; Proj. RAND)  
 (RM-4516-PR; AD-615026)

A quantum statistical procedure for studying interacting radiation fields is developed and applied to a model laser operating as a linear amplifier. The method utilizes an expansion of the density matrix in terms of a complete set of orthogonal operators originally used by Weyl. One mode of the laser field is considered to interact with a pumping mechanism and with a loss mechanism. A general solution for the density matrix is obtained and then applied to various initial conditions. It is found that a classical statistical interpretation of the results is frequently appropriate. Author

**N65-27746#** International Business Machines Corp., Yorktown Heights, N. Y. Thomas J. Watson Research Center  
**PHONON INTERACTIONS IN CRYSTALS** Quarterly Technical Report, 15 Nov. 1964-14 Feb. 1965

N. S. Shiren, M. Pomerantz, and R. J. von Gutfeld [1965] 58 p refs  
 (Contract DA-36-039-AMC-02280(E))  
 (QTR-7; AD-615960)

A quantitative theory of adiabatic fast passage in  $S = 1$  systems is presented. This theory supports the qualitative arguments previously given to explain the experimental maser results. In addition, the theory explains the dynamic gain mechanism, which is shown to be stimulated phonon-photon double quantum emission. The attenuation of 9-Gc phonons in phosphorous-doped Ge has been measured. According to the proposed theory of attenuation caused by bound electrons in degenerate states, the attenuation of the shear wave in the (100) direction should show a maximum at about 20° K. The observed attenuation shows a maximum at about 15° K, which is a qualitative confirmation of the theory. The implications of this attenuation mechanism for the thermal conductivity of doped Ge and Si are considered. Data are presented on the values of the acoustic energy velocity for quartz, sapphire, NaCl and KI. The experimental values have been determined by a special geometrical construction given by Musgrave and allow the construction of energy velocity surfaces. These energy velocity surfaces give values of the velocity that agree to within 5 percent of the observed heat pulse velocities. The multivalued nature of the energy surface is also discussed and shown to be in good agreement with the heat pulse experiments. Author

**N65-27760#** Mithras, Inc., Cambridge, Mass.  
**STUDIES OF THE EFFECT OF LASER RADIATION ON CHEMICAL ACTIVATION AND VAPOR FOG NUCLEATION** Quarterly Progress Report No. 1, Jun.-Sep. 1964

Charles S. Naiman, Mary Yvonne De Wolf, and Jack Schwartz Nov. 1964 15 p refs  
 (Contract DA-18-035-AMC-255(A))  
 (MC-64-110-RI; AD-610517)

The first objective is the study of various effects of laser radiation upon vapor and liquid systems comprised of, but not limited to, the simulant dimethyl methylphosphonate (DMMP) or air components or both. The second objective is to obtain basic information on the condensation of vapor or aerosol fogs as a result of laser radiation. The chemical shifts, coupling constants, and relaxation times of the methyl and methoxy protons in DMMP have been measured by nuclear magnetic resonance (NMR) techniques. Effects of focused and unfocused, Q-switched and non-Q-switched laser radiation on methanol vapor in a continuously sensitive cloud chamber have been

studied. A much less intense laser beam can produce condensation by incidence on a suitable surface than is required to produce tracks directly with a focused beam. A cloud chamber has been tested with low vapor pressure materials, such as water, to determine the modifications that are necessary, in order to study DMMP in the cloud chamber. Author

**N65-27833#** Illinois Univ., Urbana. Dept. of Electrical Engineering.

**JUNCTION EFFECTS IN COMPOUND SEMICONDUCTORS**

N. Holonyak, Jr., M. D. Sirkis, C. J. Nuese, and C. M. Wolfe Mar. 1965 15 p refs  
 (Contract AF 19(628)-4337)  
 (AFRL-65-271; AD-616002)

Work is described which indicates major progress has been achieved by extending to binary and ternary III-V compounds, i.e., to GaP and GaAsP, the vapor-liquid-solid (VLS) growth mechanism demonstrated recently in silicon by Wagner and Ellis. This has made possible the growth of dislocation-free III-V compounds and helps elucidate the mechanisms controlling the growth of these complicated materials. Further effort has been expended and progress achieved in the synthesis of laser-quality GaAsP. The effects of doping impurities on growth of single crystal GaAsP are mentioned. The dislocation densities observed are also mentioned. The properties of lasers fabricated to date in this program are tabulated. The behavior of threshold current in a certain crystal as a function of Fabry-Perot reflector spacing is presented. The current state of electron bombardment experiments is outlined. Author

**N65-27885#** Linde Div., Union Carbide Corp., Indianapolis, Ind.

**CZOCHELSKI RUBY** Semiannual Technical Summary Report, 1 May-31 Dec. 1964

M. N. Plöoster, H. M. Dess, and O. H. Nestor 22 Jan. 1965 41 p refs  
 (Contract Nonr-4132(00); ARPA Order 306-62)  
 (SCR-65-1; AD-610600)

The quality of Czochralski ruby was significantly improved during the report period. The gain resulted from closer controls on growth parameters, ambient atmosphere, and melt temperature. Crystals grown under preferred conditions are bubble-free and of high optical quality. Optical paths through 6-mm-diameter  $\times$  4-5cm-long  $\times$  .03-.04 wt percent  $\text{Cr}_2\text{O}_3$ , 60° orientation rubies are uniform over the rod aperture to within a wavelength (Cd 6438A) or better. The passive beam divergence observed approaches the diffraction limit. 90° and 0° rubies grown on Verneuil seed rods are of lesser quality in that order. A rough estimate based on rocking-curve data indicates an 8-second upper limit on mosaic structure in current ruby. The remaining optical inhomogeneity is due principally to chromium variations and probably residual stress. Author

**N65-27886#** Westinghouse Electric Corp., Pittsburgh, Pa. Westinghouse Research Labs.

**CHELATE WATER SOLUTION LASERS** Final Technical Summary Report, 1 Jul.-31 Dec. 1964

E. P. Riedel and R. G. Charles [1964] 72 p refs  
 (Contract Nonr-4573(00); ARPA Order 306; Proj. Defender)  
 (AD-610714)

Heavy water is considered as a liquid laser solvent. Its unique combination of good optical homogeneity, low absorption at the laser output frequency and low viscosity make it very attractive for proposed high radiance liquid laser systems. The

heavy water soluble rare-earth chelate research at the Westinghouse Research Laboratories both before the start and during the present contract is described. Chelates having adequate solubility, high quantum efficiency and improved absorption bands have been developed. The work with europium benzoyltrifluoroacetate both before and after the end of the present contract is described. To date, laser action has been achieved in 10 salts of this compound in acetonitrile near room temperature. Output beam divergence, spectral narrowing and thresholds for laser action are discussed. Author

**N65-27932#** Technical Research Group, Inc., Melville, N. Y. **DOPPLER OPTICAL NAVIGATOR** Interim Engineering Report No. 1, 1 Jun.-31 Aug. 1964

A. L. Pogoda, J. T. La Tourrette, S. Jarrett, and S. Jacobs Wright-Patterson AFB, Ohio, AF Avionics Lab. [1964] 36 p refs

(Contract AF 33(615)-1973)

(TRG-019-1-1; AD-610734)

The feasibility of techniques leading to a Doppler optical navigator for measuring instantaneous ground speed with 0.1 ft/sec accuracy at altitudes of 250 to 5000 feet is discussed. Present microwave Doppler radars are limited in short term accuracy due to the large relative bandwidth of the Doppler return signal which is caused by the large beamwidth. A Doppler optical sensor using a laser transmitter will generate a narrow beam which results in a Doppler return of narrow bandwidth. The technique discussed uses a CW-laser as a transmitter and detects the Doppler shift in the carrier frequency by optical heterodyne techniques. Signal-to-noise ratio, atmospheric effects, and spectrum width are considered. Also, the laser receiver, detector, system electronics, laser oscillator-amplifier experiments, and scanning noise measurements are included. E.E.B.

**N65-27969#** Stanford Univ., Calif. Microwave Lab. **MICROWAVE RESEARCH** Quarterly Status Report No. 24, 1 Nov. 1964-31 Jan. 1965

M. Chodorow [1965] 14 p refs

(Contract Nonr-225(48))

(ML-1316; AD-614099)

Microwave studies were continued. A program for determining properties of ZnO crystals was initiated for studying the microwave region of acoustic wave amplification in piezoelectric semiconductors. Detailed temperature dependence measurements of the line positions of absorption transitions of  $\text{Nd}^{3+}$  in the hard  $\text{LaF}_3$  lattice were continued for improving the performance of optical masers. The use of a bleachable absorber as the Q-switching element is being evaluated in the development of a tunable laser, and instrumentation for studying attenuation of ultrasonics at low temperatures was completed. The relation between energy transport velocity, group velocity, and attenuation in CdS crystals is being investigated in research on geometrical optics of acoustic waves. Studies were initiated on oscillations in semiconductors, and on plasma effects in solids. L.S.

**N65-28149#** Utah Univ., Salt Lake City. Microwave Device and Physical Electronics Lab.

**MICROWAVE DEVICE AND PHYSICAL ELECTRONICS LABORATORY CONSOLIDATED QUARTERLY REPORT, JANUARY 1-MAR. 31, 1965**

31 Mar. 1965 77 p refs

(Contracts Nonr-1288(05); AF 04(693)-439; AF 33(657)-8677; DA-039-AMC-02372(E); Grant NSF GK-29)

(MDL-Q12; AD-465082)

Research activity is reported on an effort to extend the useful frequency spectrum into the range from microwave frequency to optical frequencies and to improve existing devices and techniques in the microwave spectrum. This effort is being pursued by studies of electron beam devices, solid state devices, and plasmas. N.E.A.

**N65-28154#** Aeronutronic, Newport Beach, Calif. Applied Research Labs.

**LASER PUMPING SOURCES** Addendum to Final Technical Report

S. Byron and W. Lawrence 30 Apr. 1965 15 p ref

(Contract Nonr-4237(00); ARPA Order 306-62; Proj. Defender) (U-3104; AD-615335)

A study on the shock tube radiation source as a laser pumping source is presented. Two side pumping configurations were fabricated and used in attempts to pump a Nd-doped glass rod and ruby rods. The successful pumping of the Nd-doped glass laser rod indicates that laser action can be produced using this pump under conditions of mechanical stress on the crystal caused by high pressure gas in contact with the plastic potting material. The electrical energy equivalent inferred from the shock pumped laser output of the Nd-doped glass laser rod indicates an equivalent chemical to electrical energy conversion efficiency of about 2%. The laser crystal was not damaged, allowing the possibility of developing repetitively pulsed chemically powered laser devices based on this concept. More difficulty was encountered in pumping ruby than was anticipated and may be due to the side pumping geometry, the low spectral intensity of the shock heated xenon source at 4100Å or mechanical stress. R.N.A.

**N65-28158#** Naval Research Lab., Washington, D. C. Radiometry Branch

**COMPARISON OF UNDERWATER-ATTENUATION OF LASER WITH NONLASER LIGHT** Final Report

G. L. Knestrick, J. A. Curcio, and A. G. Rockman 5 Jan. 1965 10 p refs

(NRL-6181; AD-610692)

In a cooperative effort with the U. S. Naval Ordnance Laboratory, the attenuation coefficients of filtered Potomac River water were measured for coherent and for noncoherent light. A He-Ne gas laser served as a source of coherent red light at 6330Å, and a filtered, collimated, concentrated arc lamp furnished noncoherent light at 6355Å (red) and at 5255Å (green). The divergence of the light beam was of the order of one milliradian in all cases, and the entire cross section of the beam was always accepted by the receiver. The attenuation of red light was measured for underwater ranges of 6 to 36 m and of green light for ranges of 6 to 122 m. No experimentally significant difference was found between the attenuation coefficients measured for coherent and noncoherent light. The value obtained at 6328Å was  $0.35 \text{ m}^{-1}$ , and at 5255Å the value was  $0.097 \text{ m}^{-1}$  Author

**N65-28160#** Technical Research Group, Inc., Melville, N. Y. Quantum Electronics Dept.

**DOPPLER OPTICAL NAVIGATOR** Interim Engineering Report No. 2, 1 Sep.-30 Nov. 1964

A. L. Pogoda, J. T. La Tourrette, S. Jarrett, S. Jacobs, and S. Reich [1964] 31 p

(Contract AF 33(615)-1973)

(TRG-019-1-2; AD-610737)

Progress is reported on a program to determine the feasibility of techniques leading to a Doppler optical navigator for measuring instantaneous ground speed with 0.1 ft/sec accuracy for altitudes of 250 to 5000 feet. Present microwave Doppler radars are limited to short term accuracy due to the large relative bandwidth of the Doppler return signal which is

caused by the large bandwidth ( $2^\circ$ ). A Doppler optical sensor using a laser transmitter will generate a narrow beam which results in a Doppler return of narrow bandwidth. The approach chosen utilizes a CW laser as a transmitter and detects the Doppler shift in the carrier frequency using optical heterodyning techniques. During the report period, the work effort included: (1) scanning noise measurements with focused and collimated laser beams; (2) evaluation of fabrication techniques for a folded laser oscillator amplifier configuration; (3) experimental investigation to determine best gas pressure for  $3.5\mu$  HeXe laser; and (4) continuation of electronics design. N.E.A.

**N65-28168#** Varian Associates, Palo Alto, Calif. Central Research Lab.

**COHERENT INFRARED LASER Semiannual Technical Summary Report No. 3, 17 Jun. 1964-15 Jan. 1965**

M. W. Muller and A. Sher [1965] 17 p refs

(Contract Nonr-4244(00); Proj. Defender)

(Varian-314-3S; AD-610616)

The main purpose of this investigation was to determine the feasibility of a laser which operates on vibrational transitions. The population inversions among the vibrational states were to be produced by taking advantage of the Franck-Condon principle. Several schemes were proposed which make use of the Franck-Condon principle and all of them have now been eliminated as likely laser candidates in those molecular systems we have investigated. Author

**N65-28497#** France. Office National d'Etudes et de Recherches Aéropatiales, Chatillon-sous-Bagneux.

**USE OF LASER FOR TRAJECTORY MEASUREMENT AT GREAT RANGE [UTILISATION DU LASER POUR LA TRAJECTOMETRIE A GRANDE PORTEE]**

Claude Veret [1964] 17 p In FRENCH Presented at la Reunion sur les Equipements des Champs de tir CERES, 22 Sep. 1964 (ONERA-TP-166(1964))

The object of this report is to determine and experimentally verify the range of a laser telemetric device with a reflector on the tracking-object and with atmospheric perturbations being taken into account. A ruby laser emitter, focusing and collimating reflectors, telescopic receptor, and time dependent photoelectric cell to measure the range are described. For experimental data the reflector setup was removed to geographic locations from 20 to 90 kms from the sending and receiving device. It was determined that for horizontal trajectories the accuracy of the system is greatly dependent on atmospheric conditions with greater accuracy being obtained with increasing vertical trajectories. Trans. by J.G.

**N65-28499#** France. Office National d'Etudes et de Recherches Aéropatiales, Chatillon-sous-Bagneux.

**LASER PHOTOMETRY THROUGH PHOTOELECTRIC CELL [PHOTOMETRIE DU LASER PAR CELLULE PHOTOELECTRIQUE]**

Michel Philbert [1964] 13 p In FRENCH Presented at the Intern. Symp. on Laser Physics and its Applications, Bern, 12-14 Oct. 1964 (ONERA-TP-182(1964))

This report deals with the calibration of photoelectric cells which measure laser output through integration of the emission energy as a function of time. Calibration of the photoelectric receptor is described, and the construction and calibration of an attenuator which reduces the emission flux in proportion to the photoelectric cell receptivity is also presented. Both an absorptive and diffusive attenuator are described. Trans. by J.G.

**N65-28525#** Airtron, Inc., Morris Plains, N. J.

**GROWTH OF BROAD LINEWIDTH RUBY CRYSTALS Final Report, 1 May 1962-30 Apr. 1964**

[1964] 80 p refs

(Contract Nonr-3832(00); ARPA Order 306; Proj. Defender) (R-11-454; AD-615557)

Progress has been achieved in perfecting the techniques for the growth of ruby from flux and broadening the fluorescent linewidth by Ga additions. It has been demonstrated that large flux free ruby crystals suitable for fabrication into laser rods can be produced by spontaneous nucleation from slowly cooled molten salts. By lowering the pedestal supporting an 8 inch X 8 inch crucible until a  $200^\circ$  C gradient is obtained, and slowly cooling a  $PbF_2$  melt at  $1.5^\circ$  C per hour, large ruby plates up to  $3/8$  inches thick and 2 inches in maximum dimensions have been grown. Attempts to grow larger crystals by growth on ruby seeds were not successful, but it was established that crystals can be grown free from chromium content variation by using ruby nutrient and growing crystals in a temperature gradient under steady state conditions. Solubility of  $Al_2O_3$  in  $PbF_2$  has been measured and the effect of Cr and Ga on the solubility has been determined. Chemical analysis of the crystals shows a concentration gradient exists for Cr but not for Ga. Line broadening was achieved in ruby crystals both by the deliberate addition of Ga, and by the substitution of  $O^{2-}$  by  $F^-$  during crystal growth. Broadening in excess of  $10\text{ cm}^{-1}$  was obtained due to a combination of these factors. Two rods cut from these crystals lased at 2000 and 1200 joules respectively in a 3 inch long laser head at  $200^\circ$  K. Author

**N65-28545#** Lockheed Aircraft Corp., Burbank, Calif

**LASER BIBLIOGRAPHY**

Edward V. Ashburn Jun. 1965 66 p refs

(LR-18863)

This report consists of a bibliography of the open literature on lasers, an author index and a few notes relating to lasers. The bibliography is in four parts. A distinguishing feature of this bibliography is the classification scheme introduced in part two. The field on the study is subdivided into many topics and categories which are assigned identification numbers. These numbers are printed after each entry. In the list of categories the serial numbers of every pertinent entry appears. N.E.A.

**N65-28608#** Spectrolab, Inc., Sylmar, Calif.

**DESIGN AND FABRICATION OF OPTICAL FILTERS FOR SELECTED LASER FREQUENCIES Interim Technical Report, 1 Mar.-31 May 1965**

Samuel J. Holmes 15 Jun. 1965 14 p

(Contract AF 33(615)-2402)

(AD-466027)

Design and fabrication continued on optical filters having laser wavelengths in the  $6328\text{ Å}$  helium-neon line, the  $1.06\text{ micron}$  neodymium line, and the  $3.5\text{ micron}$  neon-xenon line. A mica interference filter technique for fabricating optical interference filters with transmission passbands having half-bandwidths of  $1$  to  $2\text{ Å}$  is described. Two optical helium-neon laser filters were evaluated and calibrated on a  $750\text{ mm}$  monochromator having a wavelength resolution of approximately  $0.1\text{ Å}$ . Auxiliary filtering is discussed. Data on the angular sensitivity of the filters was taken directly from the monochromator scan for various angles of incidence. R.N.A.

**N65-28619#** New Mexico State Univ., University Park. Research Center.

**VARIATION OF REFRACTIVE INDEX DURING LASER OPERATION Semiannual Report, Jul. 1964-Aug. 1965**

Jerald R. Izatt, Harold A. Daw, and Robert C. Mitchell Apr. 1965 61 p refs

(Contract Nonr-3531(04))

(SATR-3; AD-615422)

High resolution measurements were made of the anomalous dispersion associated with the two Stark components of the  $R_1$  absorption line in ruby. These measurements suggest that the  $R_1$  dispersion obeys the Kronig-Kramers relations; however, it is superposed on a background which is itself anomalous because the refractive index increases with increasing wavelength. These measurements cover a wavelength interval of  $0.5\text{\AA}$  and the change in background index is of the order of  $10^{-3}$  while the  $R_1$  dispersion curve deviates from the background value by  $10^{-4}$  at the maximum. The coherent radiation from a ruby laser used to illuminate the ruby sample, is absorbed less in traversing the sample than was expected on the basis of absorption measurements made with incoherent light. Accurate measurements were made of the temperature dependence of the ruby laser emission between  $63^\circ$  and  $116^\circ\text{K}$  and in a second interval between  $196^\circ$  and  $207^\circ\text{K}$ . Light shielding is described which was designed and tested to minimize pump light and ruby fluorescence at the detector in experiments with the sample optically pumped. R.N.A.

**N65-28654# RAND Corp., Santa Monica, Calif.**  
**NON-LINEAR ABSORPTION OF LASER RADIATION BY ATOMIC SYSTEMS**

H. K. Shepard and H. T. Yura Mar. 1965 45 p refs  
 (Contract AF 49(638)-700)  
 (RM-4478-PR; AD-615262)

We consider a three-level atomic system whose energy level structure allows the absorption of two laser photons via a real intermediate state, and calculate the rates of single and double photon absorption as a function of the electric field strength  $E$ . We find that for weak fields the single and double photon absorption rates are proportional to  $E^2$  and  $E^4$ , respectively, while for strong fields both the single and double absorption rates tend to constants independent of  $E$  (i.e., they saturate). We find situations where the ratio of the double photon absorption rate to the single photon rate is of the order 6. Also, we consider the case of two different laser beams (of different intensities and frequencies) interacting with a three-level atomic system. In particular, we calculate the rate of absorption of two photons, one from each beam. Finally, we give numerical estimates of a double photon absorption process in neutral chromium and potassium vapor. Author

**N65-28779# Raytheon Co., Waltham, Mass. Research Div.**  
**GASEOUS LASER RESEARCH Interim Engineering Report No. 1, 1 May-31 Jul. 1964**

F. Horrigan, S. Koozekanani, and R. Tataronis Wright-Patterson AFB, Ohio, Systems Eng. Group [1964] 57 p refs  
 (Contract AF 33(615)-1949)  
 (S-669; AD-613688)

The objective of this research effort is to achieve detailed understanding of the excitation mechanisms operative in the xenon and helium-xenon gas lasers. The method of measurement to be used in obtaining the cross sections for electron impact excitation of the various xenon levels of interest is described. A description of the first test vehicle constructed and the results of its tests are given. The experimental results are given. On the theoretical side, estimates of xenon lifetimes have been obtained by means of the Bates-Damgaard approximation. An application of the rate equation and various simple assumptions have been applied to the xenon system, resulting in expressions for laser power and population inversion as functions of electron density for one special case. The theory of a diffusion-controlled glow discharge has been modified to include the effects of the metastables found in all the rare gases. Author

**N65-28795# Library of Congress, Washington, D. C. Aero-space Technology Div.**  
**SOVIET LASER BIBLIOGRAPHY: ANALYTICAL SURVEY Surveys of Soviet-Bloc Scientific and Technical Literature**

6 May 1965 59 p refs  
 (ATD-P-65-23)

A bibliography on Soviet laser research and associated fields, covering the period from January 1961 to September 1964, is presented. Twenty-seven participant facilities were involved in the reports covered, with the majority of the material distributed among eight key institutions. These are discussed in the descending order of contributions. Interfacility correlation among these eight key institutions is described, and a brief discussion of the leading scientists' associated with the aforementioned institutions is included. A bibliography of the retrieved articles is divided into such subsections as gaseous lasers; lasers based on paramagnetic materials and on semiconductor materials; exotic lasers; spectroscopy of paramagnetic laser materials; and laser theory, applications, and effects. M.R.W.

**N65-28901# Weapons Research Establishment (Australia).**  
**A STUDY OF THE HIGH GAIN 2.026 MICRON XENON-HELIUM LASER**

B. A. See Apr. 1965 35 p refs  
 (PAD-104)

High gain lasers are of particular interest in the field of communications due to the relative ease with which they may be constructed and run. This paper presents the results of studying the 2.026 micron Xenon-Helium laser. The parameters of the Xe-He laser have been studied with the view to optimizing the power output. In particular the optimum ratio of partial pressures, the total pressure and the transmission of the mirrors have been investigated. The paper concludes with an examination of the effect of tube diameter on small signal gain. Author

**N65-28920# Naval Research Lab., Washington, D. C.**  
**LASER RESEARCH Interim Progress Report, 30 Jun. 1964-1 Jan. 1965**

J. W. Tucker, J. N. Bradford, and R. C. Eckhardt Apr. 1965 22 p refs  
 (ARPA Order 306-62)  
 (NRL-MR-1604; AD-615450)

This report reviews recent laser work of the Optics Division, Naval Research Laboratory. The major topics covered include the effect of pumping on ruby quality, optical examination of lanthanum fluoride, testing of large ruby laser rods, dc operation of the AH6 mercury tube, hologram experiments, fast Q-switching, and magnetic Q-spoiling experiments. Author

**N65-28961\*# National Aeronautics and Space Administration.**  
**Marshall Space Flight Center, Huntsville, Ala.**  
**LASER WELDING**

R. J. Schwinghammer 23 Jun. 1965 51 p refs  
 (NASA-TM-X-53285) CFSTI: HC \$3.00/MF \$0.50 CSCL 20E

A comprehensive analysis of the current state of the art in high powered lasers and laser welding is presented. Among the pertinent subjects discussed are basic laser types and the MSFC 240 kilojoule system including the gun, focussing system, power supply, pulse forming network and diagnostics. Welding aspects are considered in detail and "Q" spoiling techniques, pulse repetition rate and pulse width effects are explored. The future of continuous wave lasers for welding is discussed, and pertinent general laser information is given in the appendix. Author

**N65-29390\*# National Aeronautics and Space Administration.**  
**Goddard Space Flight Center, Greenbelt, Md.**  
**LINE WIDTH AND INVERSION RATIO OF IRON-DOPED RUTILE**

C. Curtis Johnson and Larry E. Rouzer [1964] 5 p ref Submitted for Publication  
 (NASA-TM-X-54754) CFSTI: HC \$1.00/MF \$0.50 CSCL 20E

Experimental studies of the line width and inversion ratios of iron-doped rutile ( $\text{Fe}^{3+} \cdot \text{TiO}_2$ ) are reported which demonstrate the usefulness of this material for broadband maser applications. Optimum concentration studies resulted in measured line widths of 60-Mc and inversion ratios in excess of 15:1. Inversion ratios were also calculated from the gain and paramagnetic absorption data taken over the frequency band of 2.9-4.1 gc. Inversion ratios averaged better than 15:1 over the entire band. Net gains of 20-db per inch were attained with this material. The rutile was loaded on a meander line using a conventional loading technique. Sufficient isolation was incorporated into the structure to make the amplifier gain stable and eliminate regeneration. All measurements were taken at liquid helium temperatures. Among the primary advantages found in the use of iron-doped rutile was the substantial reduction in the required magnetic field strength. S.C.W.

**N65-29444\*** # Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

#### THE APPLICATION OF MASERS TO PHYSICAL MEASUREMENTS

Walter H. Higa [1964] 3 p refs Presented at the Intern. Conf. of Microwaves, Circuit Theory and Inform., Tokyo, 7-11 Sep. 1964

(Contract NAS7-100)

(NASA-CR-58815) CFSTI: HC \$1.00/MF \$0.50 CSCI 20E

The use of masers as low noise preamplifiers in microwave communications is well known. This paper describes the use of masers in physical measurements. In particular, the changes in spin-temperature of a paramagnetic crystal as a function of various perturbations have been measured. Both spin "heating" and spin "refrigeration" of the order of  $1^\circ\text{K}$  have been measured, at a crystal temperature of  $4.2^\circ\text{K}$ , by perturbing the Boltzmann distribution in a multi-level spin system. Details of the experimental arrangement will be given with the results obtained. Author

**N65-29794** # Illinois Univ., Urbana. Dept. of Theoretical and Applied Mechanics.

#### APPLICATIONS OF LASERS TO PHOTOELASTICITY

C. E. Taylor, C. E. Bowman, W. P. North, and W. F. Swinson Mar. 1965 21 p refs (TEAM-276)

This paper discusses briefly the principles of gaseous and ruby lasers and makes comparisons of pertinent properties of lasers and conventional light sources. Since the output from a laser is a highly collimated beam of monochromatic light that can be made extremely intense and plane polarized, the eminent suitability of lasers as light sources for photoelasticity is suggested. Lasers are shown to be superior to conventional light sources, especially for the scattered light method and for high speed dynamic work. Experiments are described and results are given for using lasers for (1) the scattered light method, (2) a conventional transmission polariscope with static loads, and (3) dynamic photoelasticity. Author

**N65-29889** # Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

#### IRRADIATION ON THE SECOND OPTICAL HARMONICS

V. S. Mashkevich 12 May 1965 9 p refs Transl. into ENGLISH from Ukr. Fiz. Zh. (Kiev), v. 9, no. 2, 1964 p 226-229 (FTD-TT-65-25/1; AD-617159)

Intense optical harmonics were obtained in crystals by laser irradiation. TAB

**N65-29901** # American Optical Co., Southbridge, Mass. Research Center.

#### EXPERIMENTAL VERIFICATION OF SUN-POWERED LASER TRANSMITTER Interim Engineering Report, Apr.-Aug. 1962

D. A. La Marre [1962] 43 p refs (Contract AF 33(657)-8619) (IER-1; AD-437865)

A program of experimentation and design leading to the delivery of an experimental model of a sun-powered laser transmitter is described. Efforts to achieve sun-powered laser action using ruby, a three-level laser material are reviewed. Possible causes of the discrepancy between theoretical predictions and the unsuccessful experimental results of an earlier program are discussed. The feasibility of using four-level laser materials is investigated. A general expression is derived for the figure of merit "G" of a four-level laser in the sun-powered end-pumped configuration. In a survey of possible new laser materials, two four-level types, neodymium-doped calcium tungstate ( $\text{Nd}^{3+} \cdot \text{CaWO}_4$ ) and neodymium-doped glass, ( $\text{Nd}^{3+}$  glass) were determined to be promising. Calculation of "G" indicates that  $\text{Nd}^{3+} \cdot \text{CaWO}_4$  should laser in the sun-powered end-pumped configuration, providing the loss coefficient of the sample is not large. Thermal problems involved in cooling neodymium-doped glass are analyzed. Experimental study of samples of ruby and  $\text{Nd}^{3+} \cdot \text{CaWO}_4$  to determine important laser parameters and optical quality is reported. Also, the status of the design and construction of the sun-tracking laser mount is specified. Author

**N65-29906** # Ohio State Univ. Research Foundation, Columbus. Antenna Lab.

#### PARAMETRIC EXCITATION OF ACOUSTIC WAVES IN SIMULATED BRILLOUIN SCATTERING

W. T. Kavage 1 Jun. 1965 31 p refs

(Contract AF 33(615)-2287)

(Rept.-1935-5; AD-466177)

Stimulated Brillouin scattering is a traveling wave parametric interaction between an acoustic wave and light. There are three types of stimulated Brillouin scattering and in this thesis the basic concept of these interactions is discussed. Experimental evidence for the backward traveling acoustic wave case is presented. The existence of a threshold power density for this case is shown. The appearance of "boundary effects" and the disagreement of experimental results with the existing theories is presented. Author

**N65-30159** # Varian Associates, Beverly, Mass.

#### HYDROGEN MASER PROGRAM Interim Technical Report, 1 Jul. 1963-27 Mar. 1964

Jacques Vanier 10 Jun. 1965 40 p refs

(Contract Nonr-3570(00))

(AD-617342)

Research was conducted to determine the characteristics of the storage bulb of the hydrogen maser as part of a program for advancing the art of the hydrogen maser. Particular attention is given to wall relaxation, wall shift, exchange interactions, and maser tuning techniques. R.N.A.

**N65-30178** # Institut für Plasmaphysik G.M.B.H., Garching (West Germany).

#### ABSORPTION COEFFICIENT OF RUBY-LASER RADIATION IN FULLY IONIZED LIGHT ELEMENTS

Heinrich Hora Sep. 1964 20 p refs

(IPP-6/27)

Starting from the linearized macroscopic equations of the two-fluid-model, the absorption coefficient and refractive index of a fully ionized plasma are calculated for atomic numbers  $Z = 1$  to 10, electron temperatures  $T = 10^1$  to near  $10^5\text{eV}$ , atomic densities  $N = 10^{17}$  to  $10^{23}\text{cm}^{-3}$ , and for a light frequency  $\omega = 2.71 \cdot 10^{15}\text{sec}$  (ruby laser). A linear interaction between field and plasma is assumed. Although only the D.C. collision frequency is used, the resulting optical constants are in good agreement with Dawson's and Oberman's



- values (based on a microscopic theory), and with absorption coefficients calculated from bremsstrahlung theory. In the latter case the light frequency must be much higher than the plasma frequency, and an agreement is only possible, when stimulated emission is taken into account in the bremsstrahlung calculations.  
Author

**N65-30205** Minnesota Univ., Minneapolis.

# **OPTICAL RADAR PROBE**

John L. Kroening *In its Atmospheric Phys. Res.* May 1965 p 12-21 refs (See N65-30200 19-13)

To supplement the aerosol soundings made with the photoelectric particle counter aboard balloons, a 6943 Å ruby laser is used in an optical radar system for studying the stratospheric aerosol. Graphs are included of vertical ozone distribution, wind speed and direction, and vertical ozone and dust distribution measured simultaneously.  
C.T.C.

**N65-30208** Library of Congress, Washington, D. C. Aerospace Technology Div.

# **REVIEW OF SOVIET RESEARCH ON OPTICALLY PUMPED SEMICONDUCTOR LASERS**

Charles Shishkevish *In its Foreign Sci. Bull.*, Vol. 1, No. 7 Jul 1965 p 1-5 refs (See N65-30207 19-34)

A review is presented of the research which led to the development of the first Soviet optically pumped semiconductor laser. Both indirect and direct transition laser studies are reviewed. A description is given of a GaAs laser pumped by a ruby laser and the Stokes component of Raman scattering from nitrogen irradiated by a ruby laser.  
Author

**N65-30242#** Hughes Aircraft Co., Culver City, Calif.

# **CONTINUOUSLY PULSED LASER DEVICE FOR SURVEILLANCE Third Quarterly Report, 1 Jan.-31 Mar. 1965**

Eric J. Woodbury Fort Monmouth, N. J., Army Electron. Labs. [1965] 25 p

(Contract DA-28-043-AMC-00326(E))  
(Rept.-3: AD-617343)

Tradeoffs between tungsten lamps and xenon flashlamps as pumps for pulsed Nd:YAG lasers are investigated. The results obtained are given in detail and indicate that below 6 kc repetition rate, flashlamps are superior to tungsten lamps while above 6 kc repetition rate the reverse is true. The actual crossover region is not sharply defined so that from 3 kc to 8 kc repetition rate other system considerations could force the choice of one or the other types of lamps.  
M.R.W.

**N65-30541#** General Telephone and Electronics Labs., Inc., Bayside, N. Y. Bayside Labs.

# **INVESTIGATION OF ELECTRO-OPTICAL TECHNIQUES FOR CONTROLLING THE DIRECTION OF A LASER BEAM. PART I: BEAM DEFLECTOR DEVICES. PART 2: BEAM DEFLECTOR SYSTEMS Interim Report**

V. J. Fowler, J. Schlafer, S. Kapuscinski, R. Johnson, and P. Weiss 29 Mar. 1965 76 p  
(Contract NAS8-11459)

(NASA-CR-64222; TR-65-722.8) CFSTI: HC \$3.00/MF \$0.75 CSCL 20E

An investigation of a system for optical acquisition and tracking is described. Part I of the report is concerned with the experimental development of the key component of the system, a laser beam steerer which uses piezoelectrically driven mirrors. Consideration is given to maximum attainable resolution, frequency response, hysteresis, thermal and aging effects, and unwanted modes of deflection. Part II deals mainly with the theoretical aspects of the system. This section discusses types of scan modes, range calculations, and noise analysis

including combined effects of atmospheric and shot noise. Also described are results of a one dimensional tracking system incorporating shear plate deflectors.  
Author

**N65-30870#** Bell Telephone Labs., Inc., Murray Hill, N. J. **SOLID-STATE MASER RESEARCH (OPTICAL) Quarterly Report, 14 Nov. 1964-14 Feb. 1965**

J. E. Geusic 14 Feb. 1965 22 p refs  
(Contract DA-36-039-AMC-02333(E))  
(QR-6: AD-617184)

Part I reports the generation of repetitive, high-power pulses by repeated Q-switching of a continuously pumped YAG:Nd laser. Part II discusses the results of an experimental and theoretical study of Yb<sup>3+</sup> in yttrium-aluminum and yttrium-gallium garnet.  
Author

**N65-30979#** Library of Congress, Washington, D. C. Aerospace Technology Div.

# **FOREIGN SCIENCE BULLETIN, VOLUME I, NO. 8 A Monthly Review of Selected Foreign Scientific and Technical Literature**

Aug. 1965 74 p refs

## **CONTENTS:**

1. GIANT RADIO TELESCOPE Stuart G. Hibben p 1-8 refs
2. RAMAN SCATTERING LASERS Yuri Ksander p 9-17 refs
3. FORECASTING SOLAR FLARES D. Michaels p 18-20 refs
4. THE SECOND "MAN-IN-SPACE" SYMPOSIUM AND PROBLEMS OF VOSKHOD-2 LIFE SUPPORT SYSTEMS Boris Mandrovsky p 21-27 refs
5. EPITAXIAL GROWTH OF ALUMINUM NITRIDE THIN FILMS John G. Kourilo p 28-30 refs
6. SCIENCE & TECHNOLOGY NOTES p 31-48 refs
7. CONFERENCES p 49-59
8. BOOK REVIEWS p 65-70

**N65-31013#** Technical Research Group, Inc., East Boston, Mass.

# **FREQUENCY STABILIZED GAS LASERS. PHASE I: STUDY REPORT**

P. Rabinowitz and J. T. La Tourrette Jul. 1965 26 p refs  
(Contract NAS8-11773)

(NASA-CR-64359) CSCL 20E

"Gain-dither" laser frequency stabilization has been previously demonstrated with 3.39μ lasers at TRG. The change in parameters necessary to utilize this technique in the visible region of 6328Å are examined through both theoretical and experimental considerations. It is shown that it is necessary to use a 3.39μ laser as an optical pump gain modulator to achieve a satisfactory discriminant for stabilization. With such a pumping scheme, a breadboard stabilization system was constructed. Frequency stability of a few parts in 10<sup>10</sup> for periods of several minutes was achieved. Conclusions arrived at affecting the design of a stabilized laser package are included.  
Author

**N65-31091#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio School of Engineering.

# **A MATHEMATICAL MODEL OF A TRAVELING WAVE LIGHT AMPLIFIER IN A TRIANGULAR CONFIGURATION**

John Allan Love, III (M.S. Thesis) Jun. 1965 102 p refs  
(GSP/PHYS/65-14; AD-616707)

A traveling wave optical maser (TWOM) was placed in a recirculating configuration to make multipass amplification possible. First, a computer analysis was performed to determine the change of the population inversion in the amplifying medium and the output photon flux as the input signal travels

through the medium. Specifically, the resulting two coupled rate equations were solved using material-cavity parameters corresponding to neodymium-doped calcium tungstate in a cavity 40 nanoseconds in length. It was found that only under constant high pumping rates and in short cavity path lengths will the returned output energy be amplified again. Second, an experiment was performed utilizing ruby for both the oscillator and the amplifier. Amplification of the order of 30 db occurred.

Author

**N65-31202#** Spectra-Physics, Inc., Mountain View, Calif.  
**HIGH POWER GAS LASER IN THE VISIBLE** Quarterly  
**Progress Report, Jan. 1-Mar. 31, 1965**  
 Arnold L. Bloom and Robert L. Byer [1965] 23 p refs  
 (Contract DA-28-043-AMC-00194(E))  
 (QPR-3; AD-618106)

Work during this quarter has consisted of spectroscopic investigation of the laser emission from C-W argon, krypton, and xenon lasers and from the pulsed mercury-helium laser. The work with the noble gas ion lasers has indicated widths of 3,000 to 5,000 megacycles, with clearly resolved Zeeman splitting in fields over 700 gauss. The mercury measurements have resolved the isotope shift in the 6150 Å line and indicated a line width of about 500 megacycles. Details of the exact wavelength measurement of the mercury wavelength are presented in this report.

Author

**N65-31360#** Space Technology Labs., Inc., Redondo Beach, Calif.

**SELECTIONS FROM THE TRW SPACE TECHNOLOGY LABORATORIES LECTURE SERIES, VOLUME TWO**

Thomas L. Branigan, ed. 1965 70 p refs

**CONTENTS:**

1. THE THEORY AND APPLICATION OF MASERS AND LASERS C. H. Townes (Mass. Inst. of Tech.) p 4-13 (See N65-31361 20-16)
2. THE BIOLOGICAL EXPLORATION OF MARS E. C. Levinthal (Stanford Univ.) p 14-21 ref (See N65-31362 20-23)
3. THE EFFECTS OF HIGH-ALTITUDE EXPLOSIONS W. N. Hess (NASA, Goddard Space Flight Center) p 22-34 refs (See N65-31363 20-29)
4. THE ABUNDANCE OF THE ELEMENTS H. C. Urey (Calif. Univ.) p 35-46 refs (See N65-31364 20-06)
5. THEORETICAL ASPECTS OF THE SPACE RELATIVITY-GYROSCOPE EXPERIMENT L. I. Schiff (Stanford Univ.) p 47-50 refs (See N65-31365 20-23)
6. ENERGETIC SOLAR PARTICLES K. A. Anderson (Calif. Univ.) p 51-60 refs (See N65-31366 20-29)
7. THE ORIGIN OF PLANETARY ATMOSPHERES A. G. W. Cameron (NASA, Goddard Inst. for Space Studies) p 61-70 ref (See N65-31367 20-30)

**N65-31361** Massachusetts Inst. of Tech., Cambridge.  
**THE THEORY AND APPLICATION OF MASERS AND LASERS**

Charles H. Townes 7 Sep. 1962 *In* Space Technol. Labs., Inc. Selections from the TRW Space Technol. Labs. Lecture Ser., Vol. 2 1965 p 4-13 (See N65-31360 20-34)

Basic operation and frequency characteristics of optical masers are considered. Cesium, helium-neon, and ruby maser oscillator systems are described, and the measurement of the bandwidth of an oscillator is explained. Some applications of masers and lasers are mentioned.

M.R.W.

**N65-31459** Georgia Inst. of Tech., Atlanta.  
**STIMULATED PHOTON-PHOTON SCATTERING**  
 I. R. Gatland, L. Gold (Martin Co., Baltimore), and J. W. Moffat (Toronto Univ.) *In* Maryland Univ. Proc. of the 3d Ann. Eastern U.S. Theoret. Phys. Conf. [1964] 8 p refs (See N65-31450 20-24) Prepared jointly with Martin Co., Baltimore and Toronto Univ.

If a stimulating beam of photons is superimposed on the direct nonlinear interaction region, the resulting stimulated photon-photon scattering could be observed with foreseeable laser power. In the proposed experiment, one laser beam is reflected back by a mirror and the other is scattered at an angle equal to the incident angle  $\theta$  which satisfies Bragg's Law,  $\lambda_0 = \lambda \sin \theta$ , where  $\lambda_0$  and  $\lambda$  are the wavelengths of the incident and standing wave beams, respectively. This geometry corresponds to a so-called "brick wall" coordinate system, and the probable number of stimulated scattering events per second could be obtained. Such results indicate that it may be possible to observe stimulated photon-photon scattering in a vacuum; the main problem being the separation of the scattered photons from the Rayleigh scattering background caused by the scattering of light by atoms in the vacuum.

M.W.R.

**N65-31681#** Naval Ordnance Test Station, China Lake, Calif. Test Dept.

**FABRY-PEROT TYPE LASER MODULATORS** Technical  
**Progress Report, Jul. 1963-Jul. 1964**

Donald G. McCauley Apr. 1965 45 p refs  
 (NOTS-TP-3736; TPR-386; AD-617717)

This report describes the optical characteristics of two prototype laser modulators having the thin, flat, disk-shaped Fabry-Perot (F-P) interferometer design. The modulators are being used to investigate the use of laser radiation in communications. The report discusses the intensity modulation resulting both from the converse-piezoelectrically-induced oscillations in the physical separation of the interferometer reflectors and from the electro-optically-induced oscillations in the optical separation of the interferometer reflectors.

Author

**N65-31836#** Hughes Aircraft Co., Culver City, Calif.  
**[NEODYMIUM GLASS LASERS AND THE GENERATION OF HOLE BURNING SPECTRAL FLUXES]** Monthly Report No.  
**9, 15 Feb.-14 Mar. 1965**

L. G. Komai [1965] 37 p  
 (Contract AF 33(615)-1648)  
 (AD-464366)

Time-resolved spectral studies of Nd-glass normal lasers were made and suggest that the intricate and diverse details of the spectra observed may be characteristic of hole-burning spectral fluxes generated within the oscillator cavity. The effects on different spectral fluxes were attained using a distant-mirror mode selected oscillator. A considerable range in spectral flux was achieved using a Fabry-Perot spectral compression with thin dielectric-coated microscope glass slips inside the laser. A glass prism in the laser provided a plane-polarized output and the polarization effects were studied.

C.T.C.

**N65-31897#** Edgerton, Germeshausen and Grier, Inc., Bedford, Mass. Systems Div.

**XLS-60 AND LS-53 OPTICAL BEACON SYSTEMS** Final  
**Report, Apr. 1965**

A. L. Rotch and G. J. Lichtblau Apr. 1965 62 p  
 (Contract AF 19(628)-4049)  
 (B-3068; AFCRL-65-292; AD-464806)

The design and fabrication of a balloon-borne xenon optical beacon for laser and optical tracking and a missile-borne xenon optical beacon for optical tracking are documented. The basic elements of a xenon flashing light system are described. Design parameters and light output are determined for flat-plate reflectors and quasi-paraboloidal "tailoring" reflectors giving constant illumination at varying slant ranges. Electrical design parameters for xenon optical beacon space applications are specified and proved. Previous space flight successes are described.

Author

**N65-32069#** Korad Corp., Santa Monica, Calif.  
**GaAs LASER DIODES** Quarter Progress Report, 1 Oct.-  
**31 Dec. 1964**

- R A Sehr Ft Monmouth, N J. Army Electron Res and Develop Lab [1964] 21 p  
(Contract DA-28-043-AMC-00235(E))  
(QPR-2, AD-618464)

This report describes device development work on gallium arsenide injection lasers carried out during the second quarter of the contract period. Particular emphasis was placed on increasing the external power efficiency of the diode laser. In the course of these experiments, laser performance was studied as a function of junction depth, the junction being formed by Zn diffusion from the vapor phase. Two metallizing methods were tried in order to determine the influence of the surface treatment on laser performance. Twenty lasers fabricated by previously described techniques were delivered in the early part of this reporting period. Author

- N65-32178\*# National Aeronautics and Space Administration, Washington, D. C.

**LIGHT MODULATION AND ITS APPLICATION TO TELECOMMUNICATIONS**

Gerard Marie Aug 1965 27 p Transl. into ENGLISH from Mem. Soc. Ing. Civils France (Paris), v. 117, 1964 p 19-30 (NASA-TT-F-8762) CFSTI: HC \$2.00/MF \$0.50 CSCL 17B

The principles of light modulation and the interest light modulation offers for the long-distance transmission of information are reviewed. The main phenomena which can be brought into action for the achievement of this objective are indicated and the advantages presented by the linear electro-optical effect which appears in certain classes of crystals are discussed. Finally, the development of modulators intended for the transmission of one or more television circuits and the performances that can be expected from systems associated with He-Ne gas lasers are described. E. E. B.

- N65-32191\*# General Dynamics/Electronics, Rochester, N. Y. Research Dept.

**LASER MODULATION AT THE ATOMIC LEVEL Monthly Report No. 8, 1-28 Feb. 1965**

E. G. Brock, F. C. Unterleitner, Y. C. Kiang, and J. F. Stephany 10 Mar. 1965 14 p ref  
(Contract NASw-1008)

(NASA-CR-64436) CFSTI: HC \$1.00/MF \$0.50 CSCL 20L  
Spectroscopic study of YAG:Nd<sup>3+</sup> has continued, resulting in measurement of the temperature dependence of energy levels involved in laser emission. The separation of the levels of the <sup>4</sup>F<sub>3/2</sub> state is found to be  $84.5 \pm 0.1 \text{ cm}^{-1}$ , independent of temperature. Integrated intensities of the eight fluorescent lines between 1.05 and 1.08  $\mu$  have been measured between 180° K and 400° K. Apparent linear dependence of linewidth on temperature is noted, but is subject to refinement of data. Temperature dependence of laser threshold has been measured and is discussed on the basis of spectroscopic data. Author

- N65-32203# Cutler-Hammer, Inc., Deer Park, N. Y. Airborne Instruments Lab.

**STUDY OF SOLID-STATE AND TRAVELING-WAVE MASER TECHNIQUES Sixth Quarterly Report, Jan.-Mar. 1965**

C. Allen, J. De Gruyl, W. Heinz, S. Okwit, and J. Smith Griffiss AFB, N. Y., RADC, Jun. 1965 33 p refs  
(Contract AF 30(602)-2989)  
(RADC-TR-65-148; AD-618403)

The purpose of this program is to develop improved maser techniques and apply them to a broad-band maser system. The breadboard maser system is in its final stages of fabrication and assembly. Details of the system are described and performance tests will begin shortly. Anomalous limiting effects reported earlier for the semiconductor limiter were found to be caused by relaxation effects in the material. Measurements of a final configuration are presented and a novel pulse

modulator mode of operation for the device is described. The Gunn effect in semiconductors has been investigated as a possible pump source for traveling-wave masers. An initial study indicates that this approach to a solid-state pump source may be worthwhile. Author

- N65-32211# National Co., Inc., Melrose, Mass.  
**STUDY AND INVESTIGATION OF A PROTON MASER ANTENNA Final Report**

Alexander Ganssen, Earl Law Sloan, III, Jonathan C. Webster, and Wayne Ledder Griffiss AFB, N. Y., RADC, Apr. 1965 134 p  
(Contract AF 30(602)-2908)  
(RADC-TR-64-567; AD-619043)

A new concept in a low frequency magnetic field sensor (the proton maser antenna) is presented. The basic theory of the Promant operation is explored and calculations are given for the threshold sensitivity in terms of the system parameters. A breadboard model Promant has been constructed to verify the predicted operational behavior. A description of the model and procedures of its application in testing the basic theory are presented in detail. An investigation of several different free radical solutions is reported. The response of the Promant was studied in the frequency range from dc to 1000 c/s. The present research effort has shown that Promant is an extremely sensitive low frequency magnetic field sensor. The breadboard model represents only an initial approach to the problem. Means to improve the sensitivity by perhaps as much as 70 dB and to preserve a constant threshold response to high frequency are proposed. Author

- N65-32298# Centro di Studio per la Fisica delle Microonde, Florence (Italy)

**LASER CAVITIES Final Report**

R. Pratesi, L. Ronchi, and G. Toraldo di Francia Apr. 1965 84 p refs  
(Contract AF 61(052)-720)  
(AFCL-65-481; AD-618468)

A general analysis of the performance of a multiple axial cavity constituted by many ruby rods with plane and parallel surfaces has been carried out. The threshold condition for oscillation has been derived by applying a statistical treatment, and the theoretical results have been checked experimentally. A systematic analysis of the spectral output of the laser radiation was carried out together with an analysis of the spiking structure of the pulse. Far and near field patterns have also been studied. The extension of the multiple axial cavity to geometries other than the plane-parallel is briefly discussed. Finally the application of the multiple axial cavity to the production of giant pulse of enhanced monochromaticity has been tested, using glasses with variable transmission coefficient as light-switches. Author

- N65-32343# California Univ., Livermore, Lawrence Radiation Lab.

**EFFECTIVE FLUORESCENT LIFE TIMES IN RUBY LASER RODS**

J. A. Fleck, Jr. 15 Apr. 1964 17 p refs  
(Contract W-7405-ENG-48)  
(UCRL-7765-T(Rev. 1))

In the presence of a population inversion fluorescent life-times are reduced as a result of stimulated emission. Effective fluorescent life-times have been calculated using a Monte Carlo method for ruby rods with Brewster angle ends and roughened sides. The calculations take into account the dependence of gain and reflectivity on polarization and the dependence of gain on frequency. Results show that effective fluorescent life-times are quite insensitive to rod length but strongly dependent on rod diameter. They also indicate the possibility of oscillation in a random mode for rods of sufficiently large diameter. Author

**N65-32675#** Library of Congress, Washington, D. C. Aerospace Technology Div.  
**FOREIGN SCIENCE BULLETIN, VOLUME 1, NO. 8** A Monthly Review of Selected Foreign Scientific and Technical Literature  
 Aug. 1965 74 p refs Sponsored by Dept. of Defense

**CONTENTS:**

1. GIANT RADIO TELESCOPE S. G. Hibben p 1-8 refs (See N65-32676 21-07)
2. RAMAN SCATTERING LASERS Y. Ksander p 9-17 refs (See N65-32677 21-16)
3. FORECASTING SOLAR FLARES D. Michaels p 18-20 refs (See N65-32678 21-29)
4. THE SECOND "MAN-IN-SPACE" SYMPOSIUM AND PROBLEMS OF VOSKHOD-2 LIFE SUPPORT SYSTEMS B. Mandrovsky p 21-27 refs (See N65-32679 21-05)
5. EPITAXIAL GROWTH OF ALUMINUM NITRIDE THIN FILMS J. G. Kourilo p 28-30 refs (See N65-32680 21-17)
6. SCIENCE & TECHNOLOGY NOTES [SPACEFLIGHT MEDICAL MONITORING, EXTRAVEHICULAR ACTIVITY, GEODETIC AND DISTANCE-MEASURING INSTRUMENTS, POLAR MAGNETIC PERTURBATIONS, ETC. (USSR)] p 31-48 refs
7. CONFERENCES [LASERS (USA); ARTIFICIAL SATELLITES, CELESTIAL MECHANICS, PROBABILITY THEORY AND MATHEMATICAL STATISTICS, PHYSICAL PROPERTIES OF ROCKS, ATMOSPHERIC AND HYDROSPHERIC BOUNDARY LAYERS, AND POLYMERS (USSR)] p 49-59
8. BOOK REVIEWS [RAREFIED GASES AND EXPERIMENTAL INVESTIGATIONS IN GRAVIMETRY (USSR)] p 65-70 refs

**N65-32677** Library of Congress, Washington, D. C. Aerospace Technology Div.

**RAMAN SCATTERING LASERS**

Yuri Ksander *In its Foreign Sci. Bull.*, Vol. 1, No. 8 Aug. 1965 p 9-17 refs (See N65-32675 21-34)

Recent Soviet contributions to the theory and applications of lasers based on the stimulated Raman scattering effect are reviewed in the light of the quantum mechanical, classical, and semiclassical methods. The excitation threshold and line intensity of SRS in a variety of organic compounds and certain semiconductors are analyzed. Use of the ruby, neodymium-doped glass, and optically pumped semiconductor lasers for excitation of SRS is discussed.

Author

**N65-32851#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**SEMICONDUCTORS GENERATE LIGHT**

N. G. Basov 7 Jul. 1965 9 p Transl. into ENGLISH from Pravda (Moscow), 5 Jan. 1964 p 3  
 (FTD-TT-65-337/1+4; AD-618013)

A brief discussion of Russian research on semiconductor quantum generators is presented. Comparisons are made between semiconductor generators and generators of other types (ruby crystal, glass, and gas). The comparisons cover dimensions, radiated power, vibration mode, and efficiency. The use of the semiconductor quantum generator as an exceptionally economical source of light is discussed, and other promising applications are considered.

M.R.W.

**N65-32985#** Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaire.  
**CONTRIBUTION TO THE STUDY OF THE MOLECULAR SCATTERING OF LIGHT. USE OF A LASER AS LIGHT SOURCE [CONTRIBUTION A L'ETUDE DE LA DIFFUSION MOLECULAIRE DE LA LUMIERE. UTILISATION D'UN LASER COMME SOURCE LUMINEUSE]**

Lucien Slama (Ph.D. Thesis, Paris Univ.) 1964 78 p refs  
 In FRENCH; ENGLISH summary  
 (CEA-R-2375) CFSTI: HC \$3.00/MF \$0.75

The experiments of the molecular scattering of light have been repeated using a ruby laser as a light source. The angular distribution of the scattered light intensity has been measured when the electric vector of the incident beam is either in the plane of observation or perpendicular to that plane. In the first case a good agreement with the Rayleigh theory has been found but this is not true in the second case. The differential cross sections for scattering have been measured for various gases. The values found are two or three times larger than the ones deduced from the classical theory. The possible effect of a variation of the beam intensity upon the linearity of the scattering process has been looked for.

Author

**N65-33397#** Cutler-Hammer, Inc., Deer Park, N. Y. Airborne Instruments Lab.

**STUDY OF SOLID-STATE AND TRAVELING WAVE MASER TECHNIQUES**

J. A. De Gruyl, W. W. Heinz, S. Okwit, and J. G. Smith Griffiss AFB, N. Y., RADC, Mar. 1965 25 p refs  
 (Contract AF 30(602)-2989)  
 (RADC-TR-65-30; AD-614651)

The purpose of this program is to develop improved maser techniques and apply them to a broad-band maser system. The final design parameters of the broad-band maser system have been established and a description of the breadboard system is presented in this report. Fabrication and procurement of the breadboard components have begun. A ridged-waveguide semiconductor limiting structure has been developed and the results obtained with it are also presented in this report. Limiting characteristics have been improved; however, additional work is necessary in order to lower the limiting level so that the maser is adequately protected.

Author

**N65-33401#** Naval Ordnance Lab., White Oak, Md.  
**LASER ACTION BY ELECTRON BEAM PUMPING: STATE OF THE ART, TECHNICAL CONSIDERATIONS, AND GUIDE FOR EXPERIMENTS**

Morton Stimler Sep. 1965 47 p refs  
 (NOLTR-65-95; AD-468832)

This report relates to laser action by electron beam pumping. The papers chosen for review were selected to show the type of work being performed with electron beam pumping, and to form the basis for feasibility conclusions. Calculations intended to provide starting points for future work are also given. These include calculations of ion density in ruby, electron beam density, quantum efficiency, and critical fluorescent power. Also presented is the original data from which a family of curves is generated to predict electron penetration depths into materials of known density. The report concludes with a list of equipment for setting up an electron gun apparatus and a conceptual sketch of a compact, electron beam laser device. The conclusion reached was positive feasibility. This has since been verified. In addition, because of the advantages pointed out in the report, interest in the technique of electron beam pumping has been continually increasing.

Author

**N65-33409#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**THE POSSIBILITY OF OBTAINING A SERIES OF POWERFUL SINGLE PULSES ON A RUBY OPTICAL QUANTUM GENERATOR**

Yu. V. Bayborodin, V. L. Broude et al 25 May 1965 10 p refs  
 Transl. into ENGLISH from Ukr. Fiz. Zh. (Kiev), v. 9, no. 5, 1964 p 570-573  
 (FTD-TT-65-134/1+2; AD-467253)

Experiments with a ruby optical quantum generator (OQR) show that several powerful radiation pulses can be obtained during a single ignition. The experiments involved inserting an OQR resonator with mechanical shutter disks into an optical resonator. The shutter disks, which were rotated rapidly, had three series of openings that assured repetition times of 50, 100, and 500 msec, corresponding to a frequency range of 5.10 to 20.0 kc. Ignition duration of the pumping tube was close to 1.2 msec. The results show that if the time of pumping for the generation of the first pulse is 400 msec, generation of successive pulses can be obtained with 50 msec pumping times. It also appears that the 20 kc frequency is not an upper limit.

J.M.D.

**N65-33421#** Hughes Research Labs., Malibu, Calif.  
**LASER DEVICES EXPLORATORY INVESTIGATION** Interim Engineering Report, 5 Apr.-30 Jul. 1965  
 Viktor Evtuhov [1965] 28 p refs  
 (Contract AF 33(657)-11650)  
 (IER-7; AD-468754)

The operating life of the cw ruby laser has been extended to several hours at full power output, and to periods exceeding 40 hours at reduced power output. An increase in incremental efficiency from ~ 5 mW/100 W input to ~ 15 mW/100 W has been obtained by increasing the output coupling. No corresponding increase in the absolute power output has been obtained, however, primarily because of difficulties with the pump lamps. In attempts to improve the operation of the cw ruby laser, a number of different cavity geometries, ruby rods, and pump lamps have been experimentally investigated. The greatest difficulties were found to be associated with the pump lamps. Calculations were performed involving comparisons of the pulse and cw thresholds for ruby as well as the power outputs from three- and four-level systems. Experiments on transverse mode hopping in the cw ruby laser have been performed. In general, mode hopping was found to be less extensive in the cw laser than in the pulsed laser.

Author

**N65-33571** Spectra-Physics, Inc., Mountainview, Calif.  
**AN INFORMATION NOTE ON AN AIRBORNE LASER TERRAIN PROFILER FOR MICRO-RELIEF STUDIES**  
 Robert C. Rempel and Alan K. Parker (Aero Service Corp., Philadelphia) In Mich. Univ. Proc. of the 3d Symp. on Remote Sensing of Environment Feb. 1965 p 321-338 Prepared jointly with Aero Service Corp., Philadelphia (See N65-33550 22-13)

A gas laser ranging device which gives very high accuracy differential terrain height information from an airborne platform is presented. This presentation covers the airborne and ground test results of a feasibility model, and the development and probable performance of the final production model. A discussion of the instrument's direct applications to remote sensing and its use in conjunction with existing devices to improve their utility is presented.

Author

**N65-33686#** Space Technology Labs., Inc., Redondo Beach, Calif. Physical Electronics Lab.  
**RESEARCH ON CHARGE PARTICLE DIAGNOSTICS** Progress Report No. 4, 1-31 Jan. 1964  
 R. F. Wuerker [1964] 4 p ref  
 (Contract AF 33(615)-1035)  
 (STL-4127-6004-SU-000; AD-480936)

Experimental studies of the solid-state laser system which was put into operation and tested as a generator of intense single shot multimewatt nanosecond radiation pulses, are reported. Satisfactory operation in this mode was verified by directing light onto a whitened surface and observing the scattered radiation with a biplanar photodiode. The gain of the laser rods was measured as a function of input energy to the flash lamp by insertion of neutral density filters into the optical

resonant cavity and determined, experimentally, from the threshold for onset of stimulated emission. Tests verified that the crystals were not uniform, but consisted of hot and cold regions. The hot regions had a gain which increased linearly with energy to the flash tube. At an input of 5000 joules, measurements verified a gain of 5 along the hot regions of the crystal. The cold region saturated at gains of 3 to 4. The measured gain and recorded pulse shape were in agreement with theoretical predictions.

S.C.W.

**N65-33710#** Massachusetts Inst. of Tech., Cambridge.  
**STIMULATED BRILLOUIN SCATTERING IN LIQUIDS**  
 E. Garmire and C. H. Townes [1964] 11 p refs Submitted for Publication

(Grant NaG-330; Contract AF 19(628)-4011)  
 (NASA-CR-58214) CFSTI: HC \$1.00/MF \$0.50 CSCL 20E

Stimulated Brillouin scattering of intense laser light, with a build-up of coherent hypersonic waves, was observed in a number of liquids in an arrangement which allows multiple Brillouin scattering processes and precise measurement of the velocity of hypersonic waves. In solids, a single scattering of the incident light was observed, with a shift to lower frequencies equal to the frequency of the acoustic wave. In liquids, eight orders of successively scattered light waves appear. Each order was generated backward from the incident wave and found its way back to the laser cavity where it was amplified. A giant pulse ruby laser provided the incident light in an experimental arrangement. A glass flat with parallel sides was introduced into the beam as an additional optical resonator in order to separate longitudinal modes and produced a single mode with a frequency spread less than  $.04 \text{ cm}^{-1}$ . Stimulated Brillouin scattering was also observed with the ruby laser under normal operation, but the giant pulse system was used for measurements of frequency shifts due to high spectral purity.

R.W.H.

**N65-33773#** New York Univ., N. Y. Electron Tube Group.  
**PROJECTS DEALING WITH ADVANCED ELECTRON DEVICE TECHNOLOGY** Status Report

Feb. 1965 49 p refs  
 (Contract DA-28-043-AMC-00039(E))  
 (SR-85; AD-463584)

Advanced electron device technology is considered in summaries of government-sponsored projects and some related abstracts from non-government publications. Projects are divided into three general categories: development, evaluation, and production; device rating, reliability, life, and environmental studies; and device techniques and studies of related phenomena. Low and high power, microwave, passive, and special devices are discussed. Three projects dealing with optical masers are summarized.

M.W.R.

**N65-33895#** Westinghouse Electric Corp., Baltimore, Md. Aerospace Div.

**DEVELOPMENT OF MILLIMETER AND SUBMILLIMETER MASER DEVICES** Interim Technical Report No. 7

W. E. Hughes, C. R. Kremenek, and W. E. Richards Wright-Patterson AFB, Ohio, Electron. Technol. Lab., Jul. 1965 38 p refs  
 (Contract AF 33(657)-10472)  
 (Rept.-490G; AD-618066)

During this reporting period the major effort has been directed toward improving measuring techniques for a zero field 81-gc maser and a 9.3-gc maser. The improved techniques include new cavity designs, improved superheterodyne receivers, new dewar designs, and more reliable operation. Each improvement is described in detail in the body of this report.

Author

**N65-33899#** Purdue Univ., Lafayette, Ind. Quantum Electronics Lab.

**NONLINEAR INTERACTION OF LASER BEAM WITH SOLIDS** Final Report, Apr. 1, 1963-Jun. 30, 1965

A. K. Kamal and M. Subramanian 30 Jun. 1965 47 p refs (Contract Nonr-1100(24); ARPA Order 306-62; Proj. Defender) (AD-618473)

The first and extensively studied phenomenon is the nonlinear dc polarization that is caused by the second order nonlinear polarization. The quartz crystal is chosen as the dielectric medium. A quantitative relationship between the dc polarization and the intensity of the propagating laser beam is given. A convenient method of detecting dc polarization is presented. With this technique the elements of the second order polarization coefficient can be determined experimentally. Preliminary experimental results on the correlation between the spikings in the dc polarization and in the fundamental frequency of laser oscillation are presented. The second type of nonlinear polarization presented in this report is the initiation of a study on the generation of subharmonics at optical frequencies using high intensity laser sources. Author

**N65-33916#** Stanford Univ., Calif. Microwave Lab.  
**UNSTABLE OPTICAL RESONATORS FOR LASER APPLICATIONS**

A. E. Siegman Sep. 1964 43 p refs  
(Contracts AF 33(615)-1411; DA-36-039-SC-90839)  
(ML-1227; AD-460878)

A simple geometrical analysis developed which describes the lowest-order transverse mode in an arbitrary unstable optical resonator of large Fresnel number. The lowest mode is assumed to consist of two oppositely traveling spherical waves which uniformly illuminate the two end mirrors. The centers of curvature of these two waves (which are not in general the mirror centers of curvature) are found by requiring that each center be the image of the other upon reflection from the appropriate spherical end mirror. The resonator losses, found from simple geometrical considerations, are given by simple analytical expressions and are entirely independent of the mirror sizes. The equi-loss contours on the usual mode chart are hyperbolae. The present results agree well with more exact results calculated by Fox and Li for the unstable case, and with experimental results on a ruby laser having a divergent spherical surface ground directly onto the ruby rod. Unstable resonators of this type appear potentially useful for transverse mode control and for diffraction output coupling. Author

**N65-33995#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.  
**INVESTIGATIONS OF A SODIUM-MERCURY METAL VAPOR LASER**

Clinton Tucker Meneely (M.S. Thesis) Mar. 1965 60 p refs (SP/PH-65-15; AD-617950)

While many gaseous lasers have been developed using noble gases, relatively few gaseous lasers have been developed which operated on metallic vapors, perhaps because of the technical difficulties involved. Much of the basic research into metallic energy level systems and their interactions with other systems has been done long ago by the early spectroscopists. Their findings need only to be reappraised in the light of laser theory to be useful. It is shown that the "technical difficulties" involved in metallic vapor systems can probably be overcome with careful equipment design. TAB

**N65-33997#** Autonetics, Downey, Calif.  
**OCCUPATIONAL LASER HAZARDS—A SURVEY OF THE LITERATURE**

Marnelle Kinney 7 Jul. 1965 21 p refs  
(T5-1245/3111; AD-617913)

The need for guidelines to protect personnel involved in laser research is generally recognized. The literature reveals, however, that views differ as to what precautions should be required. This bibliography contains 48 entries arranged alphabetically by author, and includes papers published in the open literature and reports which may be obtained through the Defense Documentation Center. The period of time covered is from 1956 through May 1965. Author

**N65-34075#** Library of Congress, Washington, D. C. Aerospace Technology Div.  
**FOREIGN SCIENCE BULLETIN, VOLUME I, NO. 9 A**  
**Monthly Review of Selected Foreign Scientific and Technical Literature**  
Sep. 1965 91 p refs

**CONTENTS:**

1. COMBUSTION INSTABILITY IN SOLID-PROPELLANT ROCKETS P. Vantoch p 1-29 refs (See N65-34076 22-28)
2. SOVIET RESEARCH ON BALL LIGHTNING A. Iwanovsky p 30-41 refs (See N65-34077 22-25)
3. NEW DATA ON THE 11-YEAR SOLAR ACTIVITY CYCLE E. Gelins p 42-50 refs (See N65-34078 22-29)
4. NOCTILUCENT CLOUD RESEARCH D. W. Michaels p 51-55 refs (See N65-34079 22-13)
5. INTERSTELLAR COMMUNICATIONS V. Mutschall p 56-63 refs (See N65-34080 22-30)
6. GIANT PULSES FROM A NEODYMIUM LASER WITH A PHOTSENSITIVE LIQUID Q-SWITCH J. G. Kourilo p 64-66 refs (See N65-34081 22-16)
7. SOVIET HYDROFOILS G. Erleman p 67-72 refs (See N65-34082 22-34)

**N65-34081** Library of Congress, Washington, D. C. Aerospace Technology Div.  
**GIANT PULSES FROM A NEODYMIUM LASER WITH A PHOTSENSITIVE LIQUID Q-SWITCH**  
John G. Kourilo *In its* Foreign Sci. Bull., V. 1, No. 9 Sep. 1965 p 64-66 refs (See N65-34075 22-34)

Two Soviet experimental studies are compared with a similar U. S. study on producing giant pulses from a neodymium-doped glass laser with the aid of reversibly bleachable polymethine dye solutions. Similarities in the experimental setup and some characteristics of the laser emission were noted in both the Soviet and the U. S. studies. The stated purpose of the Soviet studies was to achieve a pulse effect in a neodymium laser similar to that previously produced in a ruby laser with reversibly bleachable phthalocyanine or kryptocyanine solutions. The most significant Soviet achievement was a single, symmetric pulse of 35-nsec width and 5-Mw peak power produced with the same polymethine dye as in the U. S. study. The energy output of this pulse was 7% of the total ordinary laser output. Author

**N65-34084#** Linde Co., Indianapolis, Ind. Speedway Labs.  
**CZOCHELSKI GROWTH OF  $\text{LaAlO}_3$**  Final Report, Jan.-May 1965  
C. D. Brandle 9 Jul. 1965 26 p  
(Contract Nonr-4793(00); ARPA Order 306; Proj. Defender) (SRCR-65-4; AD-617957)

The objective of this program was to explore the possibility of growing high optical quality  $\text{LaAlO}_3$  by the Czochralski method. The techniques developed for ruby growth were found to be directly translatable to  $\text{LaAlO}_3$  with no apparent limitations imposed by the use of a crucible. Undoped and doped ( $\text{Cr}^{3+}$ ,  $\text{Eu}^{3+}$ ) crystals of various orientations were grown.

Two major defects were encountered: color centers and twinning. Color centers were eliminated by using high purity starting materials in combination with selected growth and post-growth treatment. Two mechanisms for forming color centers are proposed and their relation to  $\text{LaAlO}_3$  defect chemistry is discussed. The dominant twin planes have been identified to be those of the (100) system. Their relation to the crystal structure of  $\text{LaAlO}_3$  has been elucidated. Isolated attempts were made to grow  $\text{BiAlO}_3$  and  $\text{PrAlO}_3$  to determine if twinning might be a problem in these potential host compositions; other growth problems were encountered indicating that an answer could be obtained only by an extensive effort beyond the bounds of the present program. Author

**N65-34108#** Northeastern Univ., Boston, Mass.  
**RESEARCH ON STORAGE DIODE LASERS** Final Technical Summary Report, 1 Apr. 1963-15 May 1964  
 Richard G. Seed and Karl M. Hergenrother [1964] 50 p refs  
 (Contract Nonr-4106(02); ARPA Order 306-62; Proj. Defender)  
 (AD-618297)

Research on a proposed storage diode laser is described in detail. The desirability of such a device in many potential applications is discussed. The design theory is presented in detail. Representative estimated numbers are presented. Four possible storage diode laser configurations are described, of which the most promising involves a low current storage pulse and high current trigger pulse in a long lifetime material. The possibility of obtaining long lifetime by the shift from direct to indirect transition is discussed. Negative experimental results with extreme high current pulses in germanium and silicon are presented. Additional experiments required for proof are described. Related experimental results on the observation of reverse emission of gallium arsenide, and on the shift of the absorption edge in germanium are presented. The design of diode laser pulsers is reviewed in general. Three specific circuit configurations are presented. An electrical double pulser is described. And finally the technology of image converters and coolers used is described. Author

**N65-34155#** Florence Univ. (Italy). Istituto di Onde Elettromagnetiche.  
**RESEARCH ON OPEN RESONATORS. PART I: THEORY OF FLAT-ROOF RESONATORS. PART II: EXPERIMENTAL TESTS OF MICROWAVE MODELS OF OPTICAL RESONATORS** Interim Scientific Report No. 1  
 G. Toraldo di Francia, P. F. Checcacci, and A. M. Scheggi May 1965 35 p refs  
 (Contract AF 61(052)-871)  
 (AFCL-65-568; AD-619879) CFSTI: HC \$2.00/MF \$0.50

A microwave or laser resonator with flat-roof mirrors is theoretically discussed. When the angle of the roof is extremely small, on the order of  $10^{-3}$  radians for microwaves or  $10^{-3}$ - $10^{-6}$  radians for optics, this resonator has some features in common with the confocal resonator. A scaling method is applied to the study of the characteristics of a laser resonator. Experimental tests performed on a F.-P. resonator with plane square mirrors operating in the X-band are described. Measurements of frequency and quality factors of the resonator modes along with field distributions are reported and the results discussed. Particularly the close correlation between mirror deformations and field patterns is shown. Author

**N65-34184#** Korad Corp., Santa Monica, Calif.  
**GaAs LASER DIODES** Quarterly Progress Report, 1 Jan.-31 Mar. 1965  
 R. A. Sehr Fort Monmouth, N. J., Army Electron. Command [1965] 24 p refs  
 (Contract DA-28-043-AMC-00235(E))  
 (QPR-3; AD-619532)

Three different methods of junction formation were employed to obtain GaAs laser diodes for room temperature operation and include diffusion of An into an n-type substrate under arsenic pressures of about 10 atmospheres, deposition of an n-type layer onto a p-type substrate from a liquid Ga melt, and vapor epitaxial growth of an n-type layer onto a p-type substrate. The initial results of these measurements indicate that the high pressure diffused junctions yield room temperature laser diodes of comparable performance to those in which the junction is grown by liquid solution epitaxy. Laser diodes in which the p-n junction was formed by vapor phase epitaxy did not lase at room temperature. Author

**N65-34192#** Joint Publications Research Service, Washington, D. C.  
**TRANSLATIONS ON COMMUNIST CHINA'S SCIENCE AND TECHNOLOGY No. 220**  
 29 Sep. 1965 27 p refs Transl. into ENGLISH from Ts'e-Liang Chi Ti-Ch'iu Wu-Li Chi-K'an (Peking), no. 1, Feb. 1965 p 96-112  
 (JPRS-32185; TT-65-32676) CFSTI: \$2.00

A review of the principles and development of the laser is presented. The use of lasers for the measurement of distance, angle, height, and geodetic surveying is also proposed. It was pointed out that in planning for laser application in survey work, the control, filtering, receiving, converting, and indicating systems must be adapted, and the effect of dense atmosphere on laser beams better understood. W.M.R.

**N65-34473#** Korad Corp., Santa Monica, Calif.  
**INORGANIC LASER MATERIALS** Interim Engineering Report, 1 Dec. 1964-31 Mar. 1965  
 Wright-Patterson AFB, Ohio, AF Avionics Lab., 15 Apr. 1965 49 p refs  
 (Contract AF 33(615)-1967)  
 (AD-466008)

Laser operation was achieved with two unary oxides ( $\text{Gd}_2\text{O}_3$  and  $\text{La}_2\text{O}_3$ ) doped with  $\text{Nd}^{+3}$  and emphasis is being placed on improvement of crystal quality and performance efficiency of these hosts, as well as the extension of this work to other primary additives. A study was undertaken of multiple doping effects (sensitized fluorescence), with emphasis on the system  $\text{Er}^{+3} \rightarrow \text{Tm}^{+3}$ . Since the effect of the  $\text{Er}^{+3}$  enhancement on  $\text{Tm}^{+3}$  fluorescence was found to increase with  $\text{Er}^{+3}$  concentration, it was decided to proceed to the limiting case where the entire host lattice acts as a sensitizer. Crystal growth of this system was initiated, and pulsed and continuous wave laser operation of this material was achieved. In the case of binary oxides, theoretical and experimental research is being conducted to evaluate  $\text{GdAlO}_3$ ,  $\text{MgO-Al}_2\text{O}_3$ , and  $\text{BeO-Al}_2\text{O}_3$  as laser hosts. A simultaneous study of hybridized growth techniques is accompanying this activity to cope with the manifold problems associated with crystal growth of polynary oxides. R.N.A.

**N65-34674#** Kollsman Instrument Corp., Elmhurst, N. Y.  
**SIMULATOR, WEAPON, FIRING AND RANGING (LASER) SYSTEM**  
 Port Washington, N. Y., Naval Training Device Center, Mar. 1965 92 p refs  
 (Contract N61339-1311)  
 (NAVTRADEVCE-1311-1; AD-619164)

This report describes Kollsman's Laser Weapon Simulator system—a device developed around a laser that simulates the important effects of a tankgun fired at a target, and accordingly enhances the training of tank gunners. The theory of operation of the laser (plus optics), and the associated power supply, is presented in detail. Procedures for installing

the simulator system on the tank and the target in the down-range area, for performing pre-operation checkout, adjustment, and alignment, for conducting training exercises, and for troubleshooting and repairing the equipment, are also provided in detail. Safety precautions necessary in aligning, operating, and repairing the equipment are carefully noted. Described are the test procedures used and the results obtained in an experiment to determine the energy reflected from a retroreflector (Scotchlite) located two hundred feet away from the Laser Weapon Fire Simulator as measured by a detector located adjacent to the laser source. The detector, a photomultiplier, established that  $0.18 \times 10^{-8}$  joules would fall on the unaided eye of the trainee and this energy level is shown to be safe. Author

**N65-34688#** Sperry Rand Research Center, Sudbury, Mass.  
**INVESTIGATION OF THE ELECTRICAL AND OPTICAL PROPERTIES OF JUNCTIONS IN VAPOR-DEPOSITED COMPOUND SEMICONDUCTORS** Final Report, 1 Jun. 1964-31 May 1965

Henry T. Minden Jun. 1965 34 p refs

(Contract AF 19(628)-4189)

(SRRC-RR-65-52; AFRL-65-498; AD-619717)

Germanium was epitaxially deposited on gallium arsenide by means of the hydrogen reduction of  $\text{GeCl}_4$ . Above  $800^\circ$ , germanium reacted with the GaAs seed to form a black powder. Proper deposition was observed below about  $750^\circ$ . Nonetheless, cross doping of the Ge layer by gallium was observed even at deposition temperatures as low as  $670^\circ$ ; the heterojunctions showed tunnel diode characteristics. Deliberately doped junctions of p-Ge on n-GaAs showed the I-V characteristics of Ge junctions, while the photovoltaic response was that of a GaAs junction. The voltage sign of the response was that of normal p-n junctions. An apparatus is described for the epitaxial deposition of GaAs. The conditions for the preparation of high-purity, smooth layers are described, and doping techniques are given. Epitaxial lasers were made by the deposition of zinc-doped epitaxial layers on n-type GaAs substrates. Junctions diffused into high-purity layers showed low-leakage currents, and some negative resistance characteristics were observed. Author

**N65-34706#** Air Force Systems Command, Kirtland, AFB, N. Mex. Air Force Weapons Lab.  
**PULSE LASER INSTRUMENTATION** Technical Report, Apr. 1962-Dec. 1963

Charles W. Bruce and Earl H. Collet Jun. 1965 67 p refs (ARPA Order 313)

(WL-TR-64-127; AD-618031)

The development of the techniques and devices used to measure pulse laser output is described. Included are discussions of principles, physical design, associated circuitry, and impedance-matching techniques. The instrumentation system consists of a total beam calorimeter suited to the laser energy range and an integrator whose signal is correlated to the calorimeter measurement. The calorimeter is either an absorbing surface or volume arranged so that the energy is well trapped. The surface absorber is a thermally isolated hollow silver sphere whose inner surface has been highly polished and whose heat capacity can be accurately calculated. The laser beam is admitted into the sphere at the focal point of a short-focal-length lens through a very small hole off center of the sphere. The volume absorber is cone-shaped as a result of various requirements and considerations. Thermistors or thermocouples are used to measure the resultant temperature rise. The use of these devices has several merits, chiefly high accuracy, stability, and relative simplicity. In addition, the devices lend themselves to the measurement of a wide range of energy densities. Author

**N65-34713#** Minnesota Univ., Minneapolis. Dept. of Electrical Engineering.

**A THEORETICAL EXAMINATION OF OFF-AXIAL DIRECTIONALITY IN LIGHT FROM OPTICAL MASERS**

Chandra M. Varma and R. J. Collins (M.S. Thesis) [1964] 63 p refs

(Contract Nonr-710(61))

(TR-2; AD-618632)

An explanation is suggested for the appearance of highly directional off-axial radiation from solid state optical masers of circular cross section which takes the form of rings in the far field. The rings are due to the propagation of high order TE and TM mode in the cavity. This is established by calculating the far field pattern when the distribution characteristic of such modes exists at the aperture of optical masers. The ring angle was related to the mode order. The rings appearance at discrete angles was explained by proving that the frequency degeneracy in a multimode cavity is dependent on the angle that wave vectors make with the axis. There are certain discrete angles at which the degeneracy is high and modes corresponding to such angles will be preferentially selected. It is shown that the amount of degeneracy at any particular angle depends on the type of nonuniformity in the reflectivity of the mirrors. Nonuniformities in the gain distribution inside the cavity lead to mode mixing with the creation of new modes with reduced thresholds of oscillation. The effect is larger for medium nonuniformities than for mirror nonuniformities by a factor proportional to the cavity length. R.N.A.

**N65-34867#** Cornell Univ., Ithaca, N. Y. Lab. of Atomic and Solid State Physics.

**DECAY OF LASER-INDUCED EXCITATIONS OF F-CENTERS** Technical Report No. 3

Dietmar Fröhlich and Herbert Mahr 30 Jul. 1965 23 p refs (Contract Nonr-401(47))

(MSC-387; AD-619072)

A strong population of excited F-center states is achieved in various alkali halides using a short intense pulse of a Q-switched ruby laser. During the presence of the excited F-centers the time dependence of their decay is measured with a fast-recording spectrometer. This is done by monitoring the absorption changes connected with the ground state or excited state populations. Using this method for crystals containing low F-center concentrations the lifetime of the excited state of F-centers in KI, RbI, CsI, RbBr and CsF is measured from  $7^\circ\text{K}$  to about  $80^\circ\text{K}$  by monitoring absorption changes in the region of the  $\beta^-$ , the  $\beta^+$ - and the F-band, respectively. For KI samples containing high F-center concentrations it is found that the decay curves are nonexponential. Author

**N65-34887#** Stanford Univ., Calif. Microwave Lab.  
**MICROWAVE RESEARCH** Quarterly Status Report No. 25, 1 Feb.-30 Apr. 1965

Jul. 1965 14 p refs

(Contract Nonr-225(48))

(ML-1351; AD-618709)

Progress is reported on acoustic wave amplification, optical masers, tunable lasers, electron-proton interactions, semiconductors, geometric optics, and solid state plasma studies. Among the specific accomplishments was the investigation of a number of commercial diffused and alloyed planar p-n junctions in which microwave radiation was found. The spectrum of the emitted radiation was estimated to reach as far as 20 to 30 kMc. The power output of these diodes under pulsed operation was of the order of one mW at X-band frequencies. Also, attention was focused on liquids with known Raman characteristics. No Stokes output was observed characteristic of an infrared transition in either benzene or chloroform. Benzene has a molecular center-of-symmetry and therefore no tuning should be possible. E.E.B.



**N65-35043#** Library of Congress, Washington, D. C. Aerospace Technology Div.

**DIFFRACTION SYNCHRONIZATION OF LASERS** Translations of Soviet-Bloc Scientific and Technical Literature N G Basov et al 16 Jul. 1965 8 p refs Transl. into ENGLISH from Dokl. Akad. Nauk SSSR (Moscow), v. 161, no. 3, 1965 p 556-559

(ATD-T-65-47; AD-618389)

Conditions are given for the existence of a radiating mirror laser in which a semiconducting layer is applied directly to the mirrors of the resonator; the said layer being divided by absorbing partitions into separate isolated cells. Such an arrangement increases the efficiency of large semiconductor lasers while suppressing parasitic generation in the plane of the mirror. The diffraction coupling coefficient of open resonators is calculated, and the stability conditions of the synchronized system are determined

TAB

**N65-35172#** California Univ., Berkeley. Space Sciences Lab. **ON THE USE OF RUTILE AS AN 8MM MASER MATERIAL** Toshio Hori and Joseph Wakabayashi 20 Nov. 1964 103 p refs revised /its Ser. No. 5, Issue No. 39 (Contract Nonr-222(54)) (AD-619191)

This report is to present some considerations and experiments which were made in the course of design of an 8 mm traveling wave maser for radio astronomy application. In Part I a brief review of solid state maser theory and paramagnetic resonances will be made. In Part II some examples of the application of the spin Hamiltonian of paramagnetic material to maser design will be presented. Also, frequency characteristics of quarter wave matching transformers will be considered. At the end of Part II, the present scheme of impedance matching between standard waveguide to maser amplifier will be presented. In Part III, some experiments which have been done to support the matching design: determination of crystal axis by Laue back reflection method; measurement of dielectric constant of materials which will be used in constructing maser amplifiers. Also, experimental considerations on broad band matching will be presented

Author

**N65-35256#** Stanford Univ., Calif. Dept. of Physics. **DIRECT MEASUREMENT OF XENON FLASHTUBE OPACITY** J. L. Emmett, A. L. Schawlow, and E. H. H. Weinberg (ONR, San Francisco) [1964] 21 p refs Submitted for Publication (Grant NsG-331)

(NASA-CR-56917) CFSTI: HC \$1.00/MF \$0.50 CSCL 09A

The optical transmission of a xenon flashtube has been measured at wavelengths from 2500 Å to 10000 Å and at currents up to 5000 amperes per cm<sup>2</sup>. It is found that the absorption increases with current and with wavelength. Above about 5000 Å and a current of 4000 amperes per cm<sup>2</sup>, a discharge tube 1 cm thick is nearly opaque. At shorter wavelengths or lower currents, the discharge is fairly transparent.

Author

**N65-35355#** Hughes Research Labs., Malibu Beach, Calif. **INVESTIGATION OF THE DC-EXCITED XENON LASER** Final Report, 24 Mar. 1964-24 Mar. 1965

Peter O. Clark, Richard A. Hubach, and James Y. Wada Apr. 1965 81 p refs Prepared for JPL (Contracts NAS7-100; JPL-950803)

(NASA-CR-67298) CFSTI: HC \$3.00/MF \$0.75 CSCL 20E

Electron energy distributions in helium-neon and xenon gas laser discharges are found to be nearly Maxwellian for small values of  $R_p$ , a product of the radius and the pressure. For larger  $R_p$  values, distributions deviate strongly from the Maxwellian. Plasma boundary effect and electron-neutral elastic collisions, the most important factors in forming the electron

energy distribution in laser discharges, are theoretically formulated by consideration of energy conservation. The theory explains the observed dependence of the distribution as a function of  $R_p$ , and experimental results are in reasonable agreement with this theory. Among the new discharge configuration designed and constructed were three hollow cathode discharge tubes and a pentode laser. None of these produced measurable output power or gain at 3.5080  $\mu$  even though they required a much larger input power than glow discharge tubes of comparable size. It was, therefore, concluded that the standard dc-excited glow discharge is the most effective and efficient gas laser discharge.

M.W.R.

**N65-35423#** Cornell Univ., Ithaca, N. Y. Lab. of Atomic and Solid State Physics.

**[EXCITED STATE SPECTROSCOPY USING A Q-SWITCHED RUBY LASER. LOCALIZED EXCITONS IN MIXED ALKALI HALIDES]** Progress Report, Oct. 1, 1964-Sep. 30, 1965

Paul L. Hartman and Herbert Mahr Jun. 1965 7 p refs (Contract Nonr-401(47))

(AD-619198)

Studies in the following areas are summarized: light absorption in the presence of excited states (strongly populated using a Q-switched laser) in KI, CsI, and RbBr; lifetimes of the relaxed excited state of F-centers in KI, CsI, RbBr and CsF; absorption edge of I<sup>-</sup> in KBr single crystals; process of F-center formation with ultraviolet light of mixed and pure alkali halides.

Author

**N65-35429#** United Aircraft Corp., East Hartford, Conn. Research Labs.

**RESEARCH PROGRAM ON NEW PEROVSKITE LASER HOST MATERIALS OF THE A[B'<sub>0.5</sub>B''<sub>0.5</sub>]O<sub>3</sub>-TYPE HAVING CUBIC CENTROSYMMETRIC LATTICE SITES** Final Report, Aug. 1, 1964-Jul. 31, 1965

F. S. Galasso, G. K. Layden, and D. E. Flinchbaugh Jul. 1965 119 p refs

(Contract Nonr-4606(00); ARPA Order 306)

(UACRL-D910269-5; AD-618936)

Powders of perovskite-type compounds having the general formula Ba(B'<sub>0.5</sub>Ta<sub>0.5</sub>)O<sub>3</sub>, where B' is a trivalent rare earth cation, In<sup>3+</sup>, Y<sup>3+</sup>, or Sc<sup>3+</sup>, were doped with trivalent laser activating ions and the fluorescent lifetimes were measured. The values and long life-times obtained for other rare earth doped phases of this type indicate that some of them may make promising laser materials. In addition, the optical properties of a number of other complex perovskite phases and some non-perovskite phases were measured. Studies involving flux growth crystals were also made. In the first investigations, small, discolored crystals of Ba(La<sub>0.5</sub>Ta<sub>0.5</sub>)O<sub>3</sub>, Ba(Gd<sub>0.5</sub>Ta<sub>0.5</sub>)O<sub>3</sub>, Ba(Lu<sub>0.5</sub>Ta<sub>0.5</sub>)O<sub>3</sub>, Ba(Sc<sub>0.5</sub>Ta<sub>0.5</sub>)O<sub>3</sub>, and Ba(Y<sub>0.5</sub>Ta<sub>0.5</sub>)O<sub>3</sub> were grown from a BaF<sub>2</sub> flux. After detailed phase diagram studies of the BaO-YTaO<sub>4</sub>-B<sub>2</sub>O<sub>3</sub> and BaO-LuTaO<sub>4</sub>-B<sub>2</sub>O<sub>3</sub> systems, clear single crystals of doped Ba(Y<sub>0.5</sub>Ta<sub>0.5</sub>)O<sub>3</sub> and Ba(Lu<sub>0.5</sub>Ta<sub>0.5</sub>)O<sub>3</sub> were grown from a B<sub>2</sub>O<sub>3</sub> flux by slow cooling. In addition, a larger single crystal of Ba(Y<sub>0.5</sub>Ta<sub>0.5</sub>)O<sub>3</sub> was grown by a modified Czochralski technique.

Author

**N65-35445#** Michigan Univ., Ann Arbor.

**OPTICAL RECTIFICATION**

Michael Bass (Ph.D. Thesis) [1964] 52 p refs

(Contract AT(11-1)-1112)

(TID-21807)

Optical rectification, or the dc effect, was studied in crystals of KDP (potassium dihydrogen phosphate), deuterated KDP, CdS, Cd(S<sub>0.75</sub> + Se<sub>0.25</sub>), and ZnTe using a one megawatt beam from a ruby laser. The detection procedure entailed mounting the crystal as the dielectric in a parallel plate capacitor and measuring the voltage induced by the dc polarization.

The relation between optical rectification and the linear electro-optic effect was experimentally verified in KDP and deuterated KDP. Available linear electro-optic data for these crystals predicts values for their dc coefficients in good agreement with the measured results. The temperature dependence of the dc effect in these crystals was identical with that of the linear electro-optic effect in the range from 120° to 300° K. The quantum mechanical prediction was verified in CdS, Cd(S<sub>0.75</sub> + Se<sub>0.25</sub>), and ZnTe. These crystals have optical absorptions nearer the ruby laser frequency than does KDP, and exhibit larger optical rectification coefficients. A large interfering signal observed in KDP using the neodymium laser may be due to a tertiary pyroelectric effect in the crystal stimulated by absorption of some of the laser beam energy. R.N.A.

**N65-35528#** Precision Instrument Co., Palo Alto, Calif.  
**COHERENT-LIGHT RECORDING TECHNIQUES** Final Report, 1 Jan.-31 Dec. 1964  
 C. H. Becker Griffiths AFB, N. Y., RADC. Jun 1965 145 p refs (Contract AF 30(602)-3272)  
 (RADC-TR-65-130; AD-618919)

Coherent-light recording/reproducing comprises a two-dimensional quantum-mechanical data process of ultimate packing density and frequency bandwidth. It is based on a continuous-wave single-mode (TEM<sub>00</sub>) laser as the coherent light source for recording and reproducing. Photographic coherent-light recording uses high-resolution microfilm as the recording medium. Diffraction-limited images of the laser are focused, electro-optically modulated, and swept over the photographic film. A photographic negative of the recordings is reproduced by means of a coherent-light beam of the same wavelength used for recording, but of strongly reduced intensity. The feasibility of electro-optical scanning for coherent-light recording/reproducing is investigated theoretically and experimentally. Single-crystal barium titanate in the paraelectric phase is used as wide-angle deflector material. A conventional servo control system is simulated, adjusting recording and reproducing to real time. Author

**N65-35530#** General Precision, Inc., Pleasantville, N. Y. GPL Div.  
**PUMPED TRANSFORMER LASERS** Technical Summary Report No. 1, 1 Nov. 1964-1 May 1965  
 Cecil B. Ellis 17 May 1965 158 p refs  
 (Contract Nonr-4718(00); ARPA Order 306; Proj. Defender) (GPL-A-31-1; AD-618896)

A new concept is presented and its analysis begun: the TRANSFORMER LASER. This arrangement is intended to convert the outputs from many lesser, and lower quality, auxiliary lasers into a single coherent plane-wavefront by absorption and re-emission in the normal transitions of a molecular gas medium. Work during this contract period has dealt exclusively with analyses of suitable gaseous media to be pumped by a battery of Nd-glass lasers near 1.06μ. The most promising gas molecule found so far for this purpose is CN, which would be obtained from the preparatory exposure of normal (CN)<sub>2</sub> gas to a pulse of UV light. The analysis to date indicates a probable potential for operation at very useful power densities, but only a few of the possible questions about such a system have yet been explored. Alternative choices for the gas medium might be Cs<sub>2</sub> or metastable nitrogen molecules. Further analysis of these molecules as well as of CN is planned for the next period. Author

**N65-35553#** Minnesota Univ., Minneapolis Dept of Electrical Engineering  
**FREQUENCY BEATS IN THE OFF-AXIS MODES OF RUBY LASERS**

Donald Theodore Davis and R. J. Collins [1965] 63 p refs (Contract Nonr-710(61))  
 (TR-3, AD-618633)

The main purpose was to observe the beat frequencies between off-axial modes, and see how parameters such as pump power and nonuniform reflectivity affect them. The microwave frequency beats between these optical laser modes are measured with a photodiode and compared with the values predicted by ideal cavity resonator theory. The observed values are seen to agree very well with those predicted. By selecting the proper nonuniform mirror reflectivity pattern, it was hoped that the thresholds of oscillation could be lowered for the local modes desired. Four different silvering patterns were used on the cylindrical ruby rods. The results indicate that it is possible to lower substantially the thresholds of oscillation of preselected modes with a proper choice of mirror silvering pattern, as long as the average reflectivity of the mirrors is not too drastically reduced. Author

**N65-35642#** Army Electronics Labs., Fort Monmouth, N. J.  
**FURTHER CONSIDERATIONS ON REGENERATIVE RUBY LASER AMPLIFIERS**  
 H. Jacobs, F. A. Brand, C. Lo Cascio, G. Novick, J. Castro (Argentine Army) et al. Mar 1965 39 p refs  
 (ECOM-2575; AD-615112)

A theoretical and experimental study has been carried out on laser amplification. An ideal laser amplifier was previously treated as a three-medium transmission system in which an electromagnetic wave was considered to travel through air, then through an active crystal during which time it underwent multiple internal reflections and finally through air again, all in a direction normal to the planar surfaces of the solid material. Experiments have been initiated to investigate the validity of the theory using ruby at liquid nitrogen temperatures. A transmission system was set up and by controlling the relative time delays in firing both rods, the properties of transmitted power gain were studied. It was found that both the oscillator and amplifier rubies when uncoated, could be made to oscillate for about 100 μsec giving a well-defined pulse of quasi CW operation. The gain of the amplifier increased as the times of the input signal from the oscillator approached the time at which the amplifier went into oscillation. With delay in signal relative to the amplifier oscillation period, an attenuation in transmission was observed. Author

**N65-35846\*#** North American Aviation, Inc. Downey, Calif. Space and Information Systems Div.  
**DEFINITION OF OPTICAL ATMOSPHERIC EFFECTS ON LASER PROPAGATION, VOLUME III**  
 H. E. Henry 4 Aug. 1965 104 p refs  
 (Contract NASw-977)  
 (NASA-CR-67382; SID-65-1084 Vol. III) CFSTI. HC \$4.00/MF \$0.75 CSCL 20E

An extended review of types of measurements and limitations of atmospheric effects on optical propagation is given. A brief analysis of cloud transmittance indicated that for relatively thin clouds the major part of the transmitted signal is coherent, while for thick clouds the majority of the transmitted light is scattered. The applicability of analytical work on wave propagation through a random media to the prediction of the time-power spectrum of the amplitude and phase fluctuations of a propagating wave is discussed, and recommendations for additional analyses are indicated. It was concluded that ray optic methods could be used to provide a good approximation to phase problems, but not to amplitude problems. A method of acquiring and categorizing data related to the laser space communications study is also presented. G.G.

**N65-35989#** Texas Instruments, Inc., Dallas. Apparatus Research and Development Lab  
**LASER DISPLAY STUDY Final Report, 2 Jan. 1964-31 Jan. 1965**

C. E. Baker and H. W. Parker Griffiss AFB, N. Y., RADC, Jul. 1965 58 p refs  
 (Contract AF 30(602)-3271)  
 (UI-903600-1; RADC-TR-65-169; AD-619443)

The results of a program to develop a demonstration breadboard of a real-time, projection display system using a laser light source are presented. The basic features of the selected approach are reviewed, and the required system performance is translated into component parameters. Progress in techniques critical to the design of a successful breadboard, such as electro-optic light modulators, acoustic light beam scanners, gas lasers, and fiber optics, is described. The operation and evaluation of the breadboard model developed are made for continued work in view of favorable results to date. Author

**N65-36115#** Joint Publications Research Service, Washington, D. C.

**TRANSLATIONS ON COMMUNIST CHINA'S SCIENCE AND TECHNOLOGY, NO. 213**

2 Sep. 1965 52 p refs Transl. into ENGLISH of 4 articles from Chinese Publ  
 (JPRS-31817; TT-65-32312) CFSTI: \$2.00

**CONTENTS:**

1. SOME PROBLEMS OF SOLID STATE CONTINUOUS STIMULATED EMISSION S.-h. Liu p 1-23 refs (See N65-36116 24-16)
2. REGENERATION OF THE SKELETAL MUSCLES J. Chu p 24-37 refs (See N65-36117 24-04)
3. ACOUSTICS T.-y. Ma p 38-43 (See N65-36118 24-23)
4. GRADUATION DESIGNS OF ENGINEERING STUDENTS p 44-45

**N65-36116** Joint Publications Research Service, Washington, D. C.

**SOME PROBLEMS OF SOLID STATE CONTINUOUS STIMULATED EMISSION**

Sung-hao Liu *In its* Transl. on Communist China's Sci. and Technol., No. 213 2 Sep. 1965 p 1-23 refs Transl. into ENGLISH from K'o-hsueh T'ung-pao (Peking), no.-7, 20 Jul. 1965 p 610-617 (See N65-36115 24-34) CFSTI: \$2.00

Some of the problems of solid state continuous stimulated emission are discussed. Threshold power and output power of such emission, working materials for the production of stimulated emission in solids, light sources and light condensing systems, cooling and heat dissipation, and the application of solid state continuous lasers are among the specific topics considered. E.E.B.

**N65-36334#** Royal Aircraft Establishment, Farnborough (England)

**SEMI-CONDUCTOR INJECTION LASERS AND LAMPS**

G. J. Burrell May 1965 66 p refs  
 (RAE-TR-65095) CFSTI: HC \$3.00/MF \$0.75

Theoretical aspects of stimulated and spontaneous emission from semiconductors are discussed, in particular in relation to fundamental absorption coefficients. The physical mechanisms involved in radiative recombination of electrons and holes induced by injection at p-n junctions are described in relation to GaAs. Fabrication techniques for GaAs injection lasers and lamps are described in detail. Methods of operation and the measured properties of these devices are reported. Suitable semiconductors for use at room temperature as injection luminescent visible lamps are discussed, and the problems involved in producing such lamps together with means of solving these problems are indicated. Author

**N65-36393\*#** College of William and Mary, Williamsburg, Va.  
**MEASUREMENT OF LIGHT SCATTERED FROM A LASER BEAM BY THE ATMOSPHERE Semiannual Status Report No. 2, 1 Dec. 1964-31 May 1965**

James D. Lawrence, Jr. [1965] 10 p

(Grant NsG-710)

(NASA-CR-67498) CFSTI: HC \$1.00/MF \$0.50 CSCL 20E

Progress is reported on an investigation of properties of the earth's atmosphere by laser backscatter techniques. During this period, the basic receiver and laser transmitter system was completed, a number of minor modifications were made, and a series of backscatter measurements were conducted with a low power ten megawatt laser system. The laser could not be adjusted to give single pulse output and consequently the observations made cannot be considered definitive. However, the results are promising and are discussed. R.N.A.

**N65-36734#** International Business Machines Corp., Yorktown Heights, N. Y. Thomas J. Watson Research Center.  
**PHONON INTERACTIONS IN CRYSTALS Quarterly Progress Report, 15 Feb.-14 May 1965**

N. S. Shiren, M. Pomerantz, and R. J. von Gutfeld [1965] 30 p refs

(Contract DA-36-039-AMC-02280(E))

(Rept.-8; AD-619273)

The signal velocity of a maser amplified 16.45 Gc/sec ultrasonics has been measured. The measured velocity was unchanged from the off resonance value. Gains of as much as 23 db were obtained. The observed velocity change for 15 db absorption was 15%. A qualitative theory of signal velocity has been derived and is in agreement with the observations. The attenuation of microwave phonons due to interaction with Ga acceptors in Ge has been observed. All the transverse and longitudinal waves propagating on the (100) and (110) directions show effects due to the impurities. The reproducibility of the measurements is rather poor, which may mean that there is some factor affecting the attenuation that is not yet appreciated. Heat pulses have been observed in Bi, Sb and germanium at about 4°K. Preliminary data on Bi and Sb leaves the question of whether electrons or phonons are the principal heat carriers unanswered. Heat pulse data for intrinsic germanium indicate that there is considerable phonon scattering though individual phonon modes are distinguishable. Author(TAB)

**N65-36869#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**MASERS**

N. G. Basov, V. S. Zuyev, and K. K. Svidzinskiy 5 Apr. 1965 40 p refs Transl. into ENGLISH of chapters 1-3 from Molekulyarnyye Generatory, Tr. Fiz. Inst., Akad. Nauk SSSR (Moscow), v. 21, 1963 p 176-199  
 (FTD-MT-64-330; AD-615213)

The feasibility of creating a maser using inversional transitions in a beam of heavy ammonia (ND<sub>3</sub>) was demonstrated using a working model of a maser on a molecular beam of ND<sub>3</sub>. On the basis of theoretical calculations it is shown that in a maser on a beam of ND<sub>3</sub>, conditions of self-excitation will be attained at reasonable parameters of the maser. Calculations of the hyperfine structure of the inversional spectrum of ND<sub>3</sub> were made, and derived data were used to analyze the absolute stability of the maser. The possibility of increasing absolute stability by line selection or by isotopic substitution of N<sup>14</sup> for N<sup>15</sup> is discussed. Included is a description of the installation, and results of studies using the working model. Experimental and theoretical results were in good agreement. S.C.W.

# 1966

## STAR ENTRIES

**N66-10260\*** General Post Office, London (England)  
**THE GOONHILLY DOWNS SPACE COMMUNICATIONS STATION**

W J Bray F J D Taylor et al /in NASA Goddard Space Flight Center Relay I Program 1965 p 671-751 refs (See N66-10226 01-31) GPO HC \$4.25; CFSTI MF \$3.50

A series of papers deals with the Goonhilly Downs space communications station in Great Britain. The station and its facilities are described, including the steerable dish aerial, the main control building and computer and control rooms, power supply, and system checking facilities. Design requirements and considerations are given for the 85-ft steerable dish aerial, and discussions are included of the dish and supporting structure, azimuth mount, elevation mechanical drive, and control system. Calibration and testing procedures are presented. Computing and data transmission for prediction steering of the aerial are discussed. Other papers deal with beam-swinging facilities of the aerial, the circularly-polarized diplexer for the aerial, and primary aerial feeds. The waveguide feeder system, the 1700 mc transmitter, low temperature thermal noise source, helium system of the maser installation, demodulating techniques, the traveling wave maser amplifier, and digital techniques used in aerial steering are also reported. M.W.R.

**N66-10395\*** Columbia Univ., New York. Columbia Radiation Lab.

**AN OPTICALLY PUMPED  $Rb^{87}$  MASER OSCILLATOR**

P. Davidovits /in NASA Goddard Space Flight Center Short-term Freq. Stability 1965 5 p refs (See N66-10381 01-07) GPO: \$1.75; CFSTI MF \$1.50 (Contract DA-36-039-SC-90789)

A self-sustained  $Rb^{87}$  maser oscillator has been developed. The maser oscillates on the  $Rb^{87}$  hyperfine transition frequency (approximately 6.835 Mc/sec). Because of its simplicity and potential frequency stability, the device promises to be a very useful frequency standard. Author

**N66-10581#** Ohio State Univ. Research Foundation, Columbus. Antenna Lab.  
**STIMULATED RAMAN SCATTERING AND RELATED NON-LINEAR OPTICAL EFFECTS**

D. A. Sealer 31 Jul. 1965 132 p refs (Contract AF 33(615)-2287) (Rept.-1935-6; AD-470341)

Through stimulated Raman scattering an optical maser becomes a source of power for narrowband electromagnetic radiation at frequencies separated from the frequency of the optical maser by integral multiples of the frequency of a molecular vibrational resonance. The generation of radiation at these frequencies is accompanied by a power decrease in the optical maser beam. The significance of stimulated Raman scattering to active device research and development is that it is a means of producing well-collimated intense narrowband optical

beams comparable to the output of an optical maser but at frequencies differing from those of the optical masers. Also, one must avoid establishing favorable conditions for the buildup of stimulated Raman scattering in optical systems in which only transmission of an intense optical beam is desired.

Author (TAB)

**N66-10583#** Martin Co., Orlando, Fla.  
**LASERS AND THEIR EFFECTS Annual Progress Report, 1 Jul. 1963-1 Mar. 1964**

James H. Burkhalter 1 Apr. 1964 50 p (Contract DA-49-193-MID-2456) (OR-3685; AD-433218)

The biological effects of lasers and laser radiation are described. Design and construction of a research laser and associated instrumentation is included. Important problems investigated for various biological researchers and the approaches used are discussed. Author

**N66-10766#** Sylvania Electric Products, Inc., Mountain View, Calif. Electronic Defense Labs.

**TECHNIQUES FOR SUPER-MODE OSCILLATION Interim Engineering Report, 1 Jun.-31 Aug. 1965**

Russell Targ, S. E. Harris, and B. J. Mc Murtry [1965] 32 p refs (Contract AF 33(615)-2884) (IER-1; AD-620849)

The work of this program is divided broadly between two main activities. The first is to obtain a more complete understanding of the physics governing the operation of the FM and super-mode lasers. The second is concerned with improving the techniques for coupling the modes of the FM laser and finding more efficient means for full power supermode conversion of the FM signal to a monochromatic output. An FM modulator was designed and built for incorporation into the laser cavity which is approximately twenty times as efficient as the modulator used successfully in all previous FM experiments. This modulator will permit work with lasers having many more oscillating modes than was previously possible. An external modulator was designed to be used for supermode conversion. This modulator is expected to have ten times the modulating capability of the previous super-mode modulators, allowing work with much higher power lasers. Attempts were made to find alternate techniques for obtaining substantial power at a single frequency. TAB

**N66-10779#** California Inst. of Tech., Pasadena. Quantum Electronics Lab.

**NONLINEAR EFFECTS IN TRAVELING WAVE LASER AMPLIFIERS Scientific Report No. 5**

D. H. Close May 1965 216 p refs (Contract AF 49(638)-1322) (AFOSR-65-0999; AD-621320)

Using semiclassical radiation theory, a formalism similar to that used by Lamb in his 'Theory of an Optical Maser' is developed for studying the amplification of vector traveling waves in a laser-type medium. The effect of the medium on the waves is given in terms of space (or time) dependent field amplitudes and phases and a nonlinear index of refraction. With particular emphasis on typical gaseous media, the effects of Doppler broadening are treated in detail for arbitrary ratios of natural to Doppler linewidths. Polarization and propagation vectors in various directions are considered, and the nonlinear effects are found to make an isotropic medium effectively anisotropic.

Lowest order nonlinear effects (due to a polarization cubic in the field amplitudes) are studied extensively, and the frequency dependence of several of these processes is presented in graphical form. In particular, the introduction of fields at new frequencies and polarization effects are considered. The characteristics of these nonlinear processes peculiar to Doppler broadened lines are discussed, and the processes are interpreted in terms of saturation and coherent modulation of the population inversion density  
TAB

**N66-10960#** Boeing Scientific Research Labs., Seattle, Wash. Plasma Physics Lab  
**PLASMA PHYSICS LABORATORY REVIEW, JANUARY-JUNE 1965**  
[1965] 29 p refs

Radio frequency modulation on light from the sun, stars, and a nebula was found and observed as a new technique. Other developments relative to communications were a practical approach to the reentry radio blackout problem and studies of a new solid state source of microwaves. Research on the control of power from hydrogen bomb reactions was aided by studies of very small, cold bits of semiconductors. Concurrently, a billion watt laser to emulate some properties of the hydrogen bomb explosion is in use. This work is conducted along with related studies of a plasma accelerator. This device holds promise of providing in a shielded laboratory a small model of an H-bomb explosion in space. Such an experimental device would be very useful in space weapons studies in addition to its contribution to research on superhot plasmas.  
R.W.H.

**N66-10962#** National Research Council of Canada, Ottawa (Ontario).  
**ESTIMATION OF HEATING OF A PLASMA BY LASERS [ABSCHATZUNGEN ZUR AUFHEIZUNG EINES PLASMAS MITTELS LASERN]**  
H. Hora 1965 23 p refs. Transl. into ENGLISH from Inst. für Plasmaphysik Rept. IPP/6/23, 1964  
(NRC-TT-1193) CFSTI: HC \$1.00/MF \$0.50

A heating model with long ionization time was considered, and cases with short ionization were discussed. Under the general assumption of completed thermalization, fusion-liberated energies of less than 1/1000th of the laser energy were obtained for normal laser energies. It was also found that the losses due to bremsstrahlung, recombination, radiation, and cyclotron radiation in the presence of magnetic fields were negligible, due to the brief times involved. Earlier estimations of whether plasmas were heated with brief laser impulses to temperatures of interest with respect to thermonuclear conditions were continued, stating that the high light field intensities would produce a nonresonant ionization. Some rough estimates were made indicating that more favorable heating was achieved with the greater densities that were attainable.  
R.W.H.

**N66-10969#** California Univ., Livermore. Lawrence Radiation Lab.  
**THE EFFECT OF HIGH VELOCITY TRANSLATION ON PHOTON CORRELATIONS IN LASER INTERFEROMETERS**  
Thomas J. Burgess 17 Aug. 1965 13 p refs  
(Contract W-7405-ENG-48)  
(UCRL-14345)

It is shown that high velocity translation of one of the mirrors of a laser Michelson interferometer diminishes the

correlation of the photons in the wave field. This diminution is manifested by deterioration of the visibility of interference effects. An expression is obtained for fringe visibility as a function of (1) the Doppler frequency-shift upon reflection from the moving mirror, (2) the line width of the laser Lorentzian spectral distribution, and (3) the optical path difference. The implications for pulsed displacement measurements are discussed.  
Author

**N66-10972#** AVCO-Everett Research Lab., Everett, Mass.  
**CONDITIONS FOR COHERENT AMPLIFICATION IN PULSED LASER ARRAYS**  
James C. Keck Oct. 1965 10 p refs  
(AVCO-Everett Res. Rept.-233)

The growth of waves in a pulsed laser amplifier has been calculated using a quasi one dimensional model. Amplification of both externally impressed and spontaneously emitted waves has been considered and it is found that the external wave must have a certain minimum intensity to prevent dumping of the laser by the spontaneous emission. The implications of the theory for the pulsed N<sub>2</sub> laser currently operating are discussed.  
Author

**N66-11060#** American Optical Co., Southbridge, Mass. Research Div.  
**FURTHER STUDY OF GLASS FIBER LASERS FOR OPTICAL DATA PROCESSING Final Report, Apr. 1964-May 1965**  
Charles J. Koester Griffiss AFB, N. Y., RADC, Aug. 1965 110 p refs  
(Contract AF 30(602)-3389)  
(AORC-4502-16-564-42; RADC-TR-65-237; AD-621227)

Investigations were undertaken to find laser effects which can be useful in optical logic functions, and to devise techniques for further development of the effects. The emphasis was on neodymium doped glass and fiber lasers. A technique was developed for generating two pulses of laser energy of sub-microsecond duration and variable time separation from 0.3 to 1 microsecond. Interactions of light from a GaAs diode laser with a pumped neodymium fiber laser were investigated. It was found that the pumped laser material acts as an excited state absorber for the 0.84  $\mu$  radiation from the diode laser. Positive steps were taken toward an optical Y junction consisting of high index glass channels imbedded in low index glass. Equations governing the behavior of a saturable absorber in fiber form have been derived. A fiber laser, consisting of a passive glass core and a neodymium doped cladding, was made to lase.  
Author (TAB)

**N66-11202\*#** National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.  
**EFFECTS OF PROPAGATION TIMES ON THE STEERING OF A NARROW-BEAM LASER TO A DEEP-SPACE VEHICLE**  
K. E. Peltzer Jun. 1965 36 p  
(NASA-TM-X-55306; X-512-65-253) CFSTI: HC \$2.00/MF \$0.50 CSCL 20E

This paper deals with one aspect of the problem associated with steering a narrow-beam LASER for communications between a planetary deep-space vehicle and an earth ground station or relay station. The area investigated is that of spacial beam offset. The introduction is a fundamental discussion of the astronomy of our solar system and is presented in order that an appreciation of the distance from earth to the other planets can be obtained. Section I presents a derivation of

- optical refraction using Snell's Law. Expressions are given for the amplitude and phase of light that has undergone refraction through a medium of known thickness and known index of refraction. Section II gives a classical derivation of the retarded vector potential. In addition, the radiation vectors as derived by Scknelknoff are defined, and the phase term is discussed in light of the problem under discussion. Section III presents the theory underlying spacial beam offset and an expression is developed that expresses the amount of offset required. For deep ranges, it is shown that the amount of spacial beam offset required does not depend on range, but depends only on the velocity of the spacecraft, aspect angle, and beamwidth of the LASER. Author

**N66-11453#** United Aircraft Corp., East Hartford, Conn. Research Labs.

**INVESTIGATION OF THE MECHANISMS ASSOCIATED WITH GAS BREAKDOWN UNDER INTENSE OPTICAL ILLUMINATION** Semiannual Report, Jan. 1-Jul. 31, 1965

Alan F. Haught and David C. Smith 27 Aug. 1965 33 p refs (Contract Nonr-4696(00); ARPA Order 306; Proj. Defender) (D920272-4; AD-619825)

The focused high-intensity optical frequency beam from a Q-spoiled ruby or neodymium laser is used to cause electrical breakdown in a test gas, and the ionization produced is examined as a function of the gas, pressure, volume within which the breakdown occurs, and frequency of radiation. With both ruby and neodymium radiation, for the gases studied breakdown in air was observed to require the highest field strength with successively lower field strengths required for breakdown in neon, helium, and argon. Studies have been carried out to examine the attenuation of the laser beam by the breakdown plasma. For beam intensities slightly above the breakdown threshold, it is observed with both ruby and neodymium incident radiation that more than half of the laser beam energy can be absorbed in the plasma produced by the breakdown and that over 90% attenuation of the laser beam can occur at later times in the optical pulse. Measurements of the attenuation of an optical beam by the breakdown plasma at times subsequent to the incident giant pulse have been made using the cw beam from a helium-neon laser. Author (TAB)

**N66-11458#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**A RUBY OPTICAL MASER**

Chih-Chiang Wang 2 Aug. 1965 22 p refs Transl. into ENGLISH from Wu Li Hsueh Pao (Peking), v. 20, no. 1, 1964 p 63-71

(FTD-TT-64-1231/1+2+3+4; AD-619425)

This paper discusses the resonant cavity, the process of oscillation and the output of radiation of optical masers. Various factors affecting the process of quantum amplification and the resultant emission are studied. Certain criteria are proposed for evaluating the quality of a resonant cavity and of the operating media, and demonstrating the feasibility of the construction of a single mode resonant cavity. Experimental results of a ruby optical maser are described and analyzed. In particular, the resultant distribution of light frequency with respect to angle of radiation may be used to explain relevant experimental evidence. Author (TAB)

**N66-11522#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**INFLUENCE OF RUBY LASER OPERATING PARAMETERS ON ENERGY OF STIMULATED EMISSION OUTPUT**

Chih-Kiang Wang, Hsing-Li Tang et al 2 Aug. 1965 11 p refs Transl. into ENGLISH from K'o Hsueh T'ung Pao (Peking), no. 2, 1964 p 151-154 (FTD-TT-64-1339/1+2+3+4; AD-619480)

The influence of certain operating parameters of the ruby laser on its energy output were investigated. These parameters were: (1) capacitance; (2) transparency of dielectric membrane; (3) optical mass of ruby rod; (4) xenon lamp input energy; (5) adjustment of resonant cavity. After these tests an output of 1 joule was obtained in the form of stimulated emission. Further measures were proposed for increasing the output energy, lowering the working temperature and increasing the size of the ruby rod. These suggestions resulted in an output of 10 joules. Author (TAB)

**N66-11607\*#** National Aeronautics and Space Administration, Washington, D. C.

**IMPROVEMENT OF FORECASTS AND ANALYSIS OF LASER MEASUREMENTS FOR SATELLITE S-66 [AMELIORATION DES PREVISIONS ET ANALYSE DES MESURES LASER POUR LE S 66]**

N. Courtois and M. Lefebvre Nov. 1965 28 p Transl. into ENGLISH of Rept. No. NL/NC/ZK/67, Centre Natl. d'Etudes Spatiales (France), 29 Apr. 1965

(NASA-TT-F-8772) CFSTI: HC \$2.00/MF \$0.50 CSCL 20E

On the basis of a number of laser measurements carried out for the satellite S-66, an attempt is made to furnish improved forecasts by utilizing the elements of the US ephemerides. A second step made it possible to analyze the measurements through a process of differential correction. Author

**N66-11665** Services Electronics Research Lab., Baldock (England).

**A GALLIUM ARSENIDE LASER RANGEFINDER USED AS AN AIRCRAFT ALTIMETER**

F. E. Birbeck and K. G. Hambleton In its S.E.R.L. Tech., J., Vol. 15, No. 3 Oct. 1965 6 p refs Submitted for Publication (See N66-11662 02-26)

A laser rangefinder is described which uses a GaAs laser operating at ambient temperature as the transmitter, and a silicon p-i-n photodiode as the detector. The design is such that adjustments to obtain optical alignment can be made easily and quickly, and the effect of vibration is virtually eliminated. The equipment has been used as an altimeter, and aircraft heights of up to 1000 feet have been measured with an accuracy of about 5 feet over a wide variety of terrain. Author

**N66-11874#** Pasadena Foundation for Medical Research, Calif.

**THE POTENTIATION OF GAMMA RADIATION WITH ENERGY FROM A RUBY LASER, MARCH 1964-JANUARY 1965**

Donald E. Rounds, John Booher, Fredy F. Strasser, and Robert S. Olson Brooks AFB, Tex., School of Aerospace Med., Jun. 1965 9 p refs

(Contract AF 41(609)-2247)

(SAM-TR-65-41; AD-469012)

Irradiation of an established line of human adeno-carcinoma cells with 20 joules from a nominal ruby laser or with 200 r gamma radiation depressed the cell number to 87.7% and 82.4% of controls, respectively. A theoretic additive effect was calculated to be 72.3% but the observed effect of the combination was only 49.7%. Therefore, laser radiation was considered to act synergistically with gamma radiation. Values below a theoretic additive effect were observed when a 6- to 48-hour

recovery period from laser radiation was permitted prior to imposing gamma radiation. The ruby laser was observed to stimulate adenosine triphosphate (ATP) synthesis, but exposing luciferase to ruby laser energy resulted in a 10% inhibition of ATPase activity. The data suggested that synergism was mediated through a reduction of energy by laser radiation to prevent restitution of injury produced by gamma radiation. Author (TAB)

**N66-11926#** Argonne National Lab., Ill.  
**OPTIMUM DESIGN OF HIGH-PRESSURE, LARGE-DIAMETER, DIRECT-NUCLEAR-PUMPED, GAS LASERS**  
 James A. De Shong, Jr. Jun. 1965 52 p refs  
 (Contract W-31-109-ENG-38)  
 (ANL-7030) CFSTI: \$2.00

The principles of laser operation are discussed with emphasis on gas lasers. Previous work in small diameter, direct-nuclear-pumped, gas lasers is surveyed. Techniques are developed for optimizing laser tube dimensions and gas pressure to obtain most efficient use of the nuclear fragment energy. These techniques are applied to calculate high-pressure, large-diameter, laser tubes for  $U^{235}$  and for  $B^{10}$  which both exhibit theoretical efficiencies two orders of magnitude larger than previous small diameter tubes. The  $B^{10}$  laser appears feasible, because electrically pumped lasers of similar dimensions and pressure have operated in the pulse mode with up to 80-W output. The  $U^{235}$  laser is much larger in diameter and may require multipath operation. Author

**N66-11935#** General Electric Co., Schenectady, N. Y. Advanced Technology Labs.  
**A REVIEW OF NON-LINEAR OPTICS**  
 G. C. Baldwin Jun. 1965 103 p refs  
 (Rept.-65GL94)

A review of nonlinear phenomena which have recently been discussed in research with intense light sources, especially lasers, is presented. The framework of linear physical optics is briefly given, followed by descriptions of various effects which imply nonlinear responses in optical media. Harmonic generation, rectification, frequency mixing, Raman and Brillouin scattering, and other nonlinear processes are described in detail, and a semiclassical theory presented. A bibliography of significant papers is appended. C.T.C.

**N66-11992#** American Optical Co., Southbridge, Mass. Research Div.  
**THEORY OF INDUCED AND SPONTANEOUS EMISSION**  
 Final Report, May 1964-Jun. 1965  
 Saul M. Bergmann Jul. 1965 94 p refs  
 (Contract AF 19(628)-4156)  
 (AFCRL-65-505; AD-622100)

The problem of induced and spontaneous emission is investigated for an atomic two-level system and incident beams of radiation which are either in a coherent state or in a stationary state (contain a definite number of photons). The frequency spectrum of the incident beam is assumed to be narrow compared to the natural linewidth of the system. The spontaneous emission for frequencies within the narrow band of the incident radiation is sharply reduced compared to the prediction of the natural line-shape. A hole is burned in the natural line-shape within the narrow frequency band, thus effectively quenching the spontaneous emission at some frequency within the band. This effect is shown to occur both

for the coherent and stationary beams. Also quantities proportional to the induced and spontaneous probability amplitudes and the lifetimes are computed for times comparable to and long compared to the free lifetime of the state

Author (TAB)

**N66-12043#** California Inst. of Tech., Pasadena. Quantum Electronics Lab.  
**SPONTANEOUSLY RADIATING ATOM IN CAVITY FIELDS**  
 Scientific Report No. 4  
 Carl J. Buczek Apr. 1965 155 p refs  
 (Contract AF 49(638)-1322)  
 (AFOSR-65-1000; AD-621319)

The characteristics of spontaneous emission from an atom which interacts with a coherent light wave are determined. The competition between coherent photons and spontaneous photons is treated in detail for a system consisting of a stationary atom, an open cavity and spatial fields. It is found that the interaction with the coherent field modifies the spectral distribution of spontaneous radiation from the atom. For spontaneous transitions involving an atomic state which interacts with the coherent field, the spectral distributions can no longer be described by Lorentzian functions. The new distributions exhibit a broadening and splitting for strong interactions between the atom and the coherent field. It is shown that the qualitative features of these new distributions can be predicted from the energy-level diagram of the atom-cavity system. The net probability of the system gaining a coherent or cavity photon is calculated by integrating over the emitted spontaneous frequencies. The equivalence of this approach to the method of computing probabilities by integrating over time is demonstrated by using Parseval's theorem. Author (TAB)

**N66-12048#** Korad Corp., Santa Monica, Calif.  
**SOLID STATE-LASER AMPLIFIER Quarterly Progress Report**  
 J. H. Boyden, John Free, A. H. Gillmer, R. H. Hoskins, R. C. Pastor, and H. Schultz May 1965 39 p refs  
 (Contract DA-36-039-AMC-0070(E))  
 (QPR-8; AD-620685)

Observations of the spatial non-uniformities of laser gain indicated that the origin of this effect is laser light trapped within the ruby rod. Experimental and theoretical work with laser amplifier systems resulted in the development of a 3000 MW amplifier system. Systems with output half-power pulsewidths in the 50-250 microsec range were also developed. The limits of achievable performance were investigated, with allowances made for technologically feasible improvements and differing amplifier and oscillator component configurations. Amplification of the output of a curved-mirror interferometer was shown to be the most practical approach for producing high-brightness and spikeless laser output.  $Y_2O_3:Eu^{+3}$  crystals of 1/4-inch diameter and one-inch length were grown. Difficulties encountered in lasing suggest the use of  $Gd^{+3}$  as an additive ion.

Author (TAB)

**N66-12120#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**OPTICAL COMMUNICATIONS**  
 Chia-Sung L.C.-lu 28 Jun. 1965 11 p Transl. into ENGLISH from K'o Hsueh Ta Chung (China), no. 2, 1964 p 46-47,64 (FTD-TT-65-95/1+2+3+4; AD-621053)

A general description of the theory and applications of optical communication systems is presented. TAB

**N66-12270#** Library of Congress, Washington, D. C. Aerospace Technology Div.  
**LASER-INDUCED NONLINEAR OPTICAL EFFECTS: COMPREHENSIVE REPORT** Surveys of Soviet Scientific and Technical Literature

\* Yuri Ksander 29 Oct 1965 52 p refs  
(ATD-P-65-74)

Recent Soviet research dealing with laser-induced non-linear optical effects, Raman scattering, and laser-induced gas breakdown is reviewed. Multiphoton processes, generation of harmonics, and the amplification and modulation of light in nonlinear media are discussed. Stimulated Raman scattering theory and applications to semiconductors and organic liquids are considered. M.W.R.

**N66-12355#** Electro-Optical Systems, Inc., Pasadena, Calif.  
**HIGH POWER LASER AMPLIFIER CHAIN TECHNIQUES**  
**First Quarterly Progress Report, 14 Jul.-14 Oct. 1964**

G. L. Clark. Griffiss AFB, N. Y., RADC, Sep. 1965 50 p refs  
(Contract AF 30(602)-3502)  
(EOS-5550-Q-1; RADC-TR-64-516; AD-621979)

This report describes work directed toward the development of an optical radar transmitter using the master oscillator-power-amplifier (MOPA) concept. The system will employ a CW YAG:Nd<sup>3+</sup> oscillator and a chain of amplifiers, taking advantage of the power-handling capability of neodymium-doped glass to produce adequate power for long distance surveillance. Because a laser amplifies equally well in both directions and generates noise by spontaneous decay, careful design is necessary to avoid regeneration in the amplifier chain, prevent amplifier noise in the reverse direction from swamping the oscillator, control depumping caused by superradiance, and provide a good signal-to-noise ratio in the transmitted signal. This report includes discussion of cw oscillator and pulsed amplifier designs, measurements of amplifier gain, and calculations of the limitations imposed by superradiance. Author (TAB)

**N66-12398#** Hughes Aircraft Co., Culver City, Calif.  
**PULSED LASER OSCILLATOR ADVANCED DEVELOPMENT MODEL** Fourth Quarterly Report, 1 Apr.-30 Jun. 1965  
E. J. Woodbury Jul. 1965 6 p  
(Contract DA-28-043-AMC-00326(E))  
(ECOM-00326-4; AD-622268)

The report contains the supporting arguments for the change in direction of the contract from a 1500 pulse per second head to a 5000 pulse per second head, which change has just been negotiated. In addition, the results of some pertinent Company-sponsored work are given. Author (TAB)

**N66-12404\*** National Aeronautics and Space Administration, Washington, D. C.  
**NASA'S PROGRAM IN ADVANCED RESEARCH AND TECHNOLOGY**  
Raymond L. Bisplinghoff. In its NASA Univ. Program Rev. Conf. 1965 7 p (See N66-12401 03-34) GPO: HC \$1.50; CFSTI: MF \$2.00

The program in advanced research and technology is carried out at the Langley, Ames, Lewis, Flight, and Electronics Research Centers. Resources amounting to about 10% of the NASA budget are invested in this program. The technologies of space flight are viewed in three steps: from Earth to Earth orbit; from Earth orbit to Moon; and from Moon to planets. The program is designed to improve the reliability of all three steps and for conceiving and developing the new concepts required for the third step which is discussed in detail. The field of energy conversion, materials problems, and the process of measuring or sensing and then using the data obtained to control the flow of energy are considered. Also, communications and the use of lasers for communications and tracking are mentioned. The first space flight experiments with the use of lasers for communications and tracking were conducted with

Explorer XXII satellite which was equipped with corner reflectors designed to reflect a laser beam transmitted from the ground back along its original path. Tracking is accomplished through a computer which aligns the laser beam with the predicted satellite position. E.E.B.

**N66-12450#** Michigan Univ., Ann Arbor. Willow Run Labs.  
**SEMICONDUCTOR LIGHT SOURCES**

Alfred E. Attard Sep. 1965 31 p  
(Contract DA-28-043-AMC-00013(E)); Proj. Michigan)  
(Rept.-6400-42-T; AD-470376)

The development of semiconductor light sources and the applications of such sources were the objectives of this project. Some 250 GaAs diodes were prepared, most of these exhibited injection electroluminescence, and a few appeared to be capable of producing coherent radiation. Modulation of the light output at frequencies up to 10 Mc/s has been achieved. Study of these semiconductor light sources for photographic recording of data at high information rates was undertaken. Recordable data at frequencies up to 350 Kc/sec have been demonstrated with possibilities of extending this capability into the megacycle range. Multielement light sources have been fabricated to demonstrate the possibility of simultaneous multichannel recording of data. Author (TAB)

**N66-12624#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**OPTICAL QUANTUM CRYSTAL GENERATOR WITH EXCITATION BY FAST ELECTRONS**

N. G. Basov, O. V. Bogdankevich, and A. G. Devyatkov 15 Jun. 1965 8 p refs Transl. into ENGLISH from Tr. Fiz. Inst. Akad. Nauk SSSR (Moscow) 1964 7 p  
(FTD-TT-65-555/1+2+4; AD-620973)

An optical quantum generator (LASER) was obtained pumping a cadmium sulfide single crystal with an electron beam, and its spectrum was studied. TAB

**N66-12644#** Library of Congress, Washington, D. C. Aerospace Technology Div.

**FOREIGN SCIENCE BULLETIN, VOLUME NO. 11**  
Nov. 1965 68 p refs Sponsored by Dept. of Defense

**CONTENTS:**

1. ANALYSIS OF ATMOSPHERICS PROPAGATED OVER LAND AND SEA MASSES S. G. Hibben p 1-11 refs (See N66-12645 03-13)

2. ELECTRON-BEAM-PUMPED CdTe AND GaSe LASERS C. Shishevich p 12-17 refs (See N66-12646 03-16)

3. ORIGIN OF THE EARTH'S RADIATION BELTS AND THE CORRELATION BETWEEN THE BELTS AND THE IONOSPHERE E. Gelins p 18-28 refs (See N66-12647 03-29)

4. A NEW METHOD FOR SOLVING LAMINAR BOUNDARY-LAYER PROBLEMS V. Klein p 29-32 refs (See N66-12648 03-12)

5. THE SEARCH FOR HIGH-TEMPERATURE SEMICONDUCTOR MATERIAL (USSR) J. G. Kourilo p 33-37 refs (See N66-12649 03-26)

6. HIGHLIGHTS OF SOVIET BIOASTRONAUTICS AT THE 16TH IAF CONGRESS B. N. Mandrovsky p 38-48 refs (See N66-12650 03-05)

**N66-12646** Library of Congress, Washington, D. C. Aerospace Technology Div.

**ELECTRON-BEAM-PUMPED CdTe AND GaSe LASERS**

Charles Shishevich. In its Foreign Sci. Bull., Vol. 1, No. 11 Nov. 1965 p 12-17 refs (See N66-12644 03-34)

The Soviet experimental research on recombination radiation of CdTe excited by a beam of electrons is reviewed. An operating electron-beam CdTe laser is described, as is the



first III-VI laser pumped by a beam of electrons (GaSe).  
first III-VI laser pumped by a beam of electrons (GaSe).

Author

**N66-12795#** Ohio State Univ. Research Foundation, Columbus.

**SOME STUDIES OF THE NEAR-HEMISPHERICAL RESONATOR GAS LASERS**

F. G. Gebhardt 30 Oct. 1964 78 p refs

(Contract AF 33(657)-11195)

(Rept.-1641-6; AD-468328)

The problem of obtaining laser operation purely in the dominant transverse mode, as desired for heterodyning purposes, is considered here. The pertinent results of the resonator theory of Boyd, Gordon and Kogelnik are presented, along with the technique to be used for adjusting the hemispherical resonator laser for dominant mode operation and for identifying this condition using the photomultiplier beats between transverse modes. The experimental results, obtained using a commercially available gas laser, showed that pure dominant mode operation may be obtained at high excitation levels and that the technique of observing photo-beats is necessary to accurately identify this condition. Also, the measured laser transverse mode beam patterns and resonant frequencies as deduced from the beat data, correlated well with those calculated from the optical resonator theory.

Author (TAB)

**N66-12799#** Westinghouse Electric Corp., Pittsburgh, Pa. Quantum Electronics Dept.

**INVESTIGATION OF THE USE OF A LASER AS A SPECTROGRAPHIC SOURCE Final Report, 1 Jun. 1964-31 May 1965**

G. A. Klotzbaugh, A. L. Wolfe, J. E. Paterson, and T. A. Osial 30 Jun. 1965 102 p refs

(Contract AF 19(628)-4184)

(AFCRL-65-586; AD-622102)

The possibilities are studied of using a laser beam in spectrographic analysis. High intensity focused laser radiation is used to bombard various metal targets. An ionized plume is thereby produced, leaving behind a small crater in the target surface. This vapor is analyzed by a conventional spectrograph, thus producing a recorded spectrum that is characteristic of the target surface. This problem is studied both experimentally and theoretically, and it is concluded that best results are obtained when the plume is cross excited by a secondary source immediately after the laser generates the plume. Two types of lasers are used in the study. One is a normal laser having a few hundred spikes of energy in each pulse. The total pulse duration is of the order of a millisecond. The second type is a giant spike laser, in which all of the energy is released in one pulse of about a hundred nanosecond duration. The merits of each as spectrographic tools are discussed.

Author (TAB)

**N66-12814#** United Aircraft Corp., East Hartford, Conn. Research Labs.

**ULTRASONIC LASER MODULATION TECHNIQUES Final Report, 1 Jul. 1964-30 Jun. 1965**

A. J. De Maria, D. E. Flinchbaugh, and G. E. Danielson, Jr. 20 Oct. 1965 119 p refs

(Contract DA-28-043-AMC-00259(E))

(D920259-12; AD-622575)

The feasibility of internally modulating the output of solid-state lasers without having to insert lossy elements into the Fabry-Perot feedback interferometer has been demonstrated by the propagation of focused acoustic waves within a glass laser rod. These studies have shown that the establishment of

an alternating converging-diverging waveguide effect by the propagation of acoustic waves within the laser interferometer results in gating of a  $\text{Nd}^{3+}$  glass laser at the acoustic frequency, an increase in output energy by as much as 100%, and an absence of discrete axial modes under gating conditions. The complexity of the integral equations describing the slope and trajectories of light rays traversing various periodic refractive index variations generated by acoustic waves led to the use of analog computer techniques for solving three differential equations for the slope and trajectories of the light rays. The use of the slope solutions for designing a Fabry-Perot laser interferometer configuration for pulse shaping the output of laser oscillators is described. The trajectory solutions describe the operation of the converging-diverging waveguide modulation effect within the laser's interferometer.

TAB

**N66-12838#** Electro-Optical Systems, Inc., Pasadena, Calif. **OPTICAL TRANSMITTER TECHNIQUES Technical Report, 15 Jul.-15 Oct. 1964**

M. L. Bhaumik and L. J. Nugent Griffiss AFB, N. Y., RADC, Sep. 1965 17 p refs /ts Rept.-5180-Q-2

(Contract AF 30(602)-3440)

(RADC-TR-64-526; AD-621630)

Work is described directed toward the design and fabrication of a gas laser oscillator and a solid-state chelate laser operating at wavelengths ranging from 5.0 to 0.3 microns. During the reporting period, the optimized material using sensitized fluorescence was tested for laser action. Under the high energy intensities of flashes, photo-reaction products are detected. This problem has been solved using new sensitizers and/or new solvents. But the quantum field is somewhat low with these sensitizers. Work is in progress to improve the quantum field. The mechanisms of the energy transfer in chelates have been further clarified and it is shown that the optical pumping scheme in the rare-earth chelate to achieve population inversion does not involve any inefficient process.

Author (TAB)

**N66-12860\*#** Arkansas Univ., Little Rock. Graduate Inst. of Tech.

**INVESTIGATION OF LASER PROPERTIES RELEVANT TO THE MEASUREMENT OF DIFFERENT PHYSICAL PARAMETERS Semiannual Status Report, 1 Mar.-1 Sep. 1965**

M. K. Testerman 11 Oct. 1965 65 p refs

(Grant NSG-713)

(NASA-CR-68235) CFSTI: HC \$3.00/MF \$0.75 CSCL 20E

Research is reported in the following areas: mapping of vibrating surfaces, the use of a laser to measure the frequency having a few hundred spikes of energy in each pulse. The total pulse duration is of the order of a millisecond. The second type is a giant spike laser, in which all of the energy is released in one pulse of about a hundred nanosecond duration. The merits of each as spectrographic tools are discussed.

Author (TAB)

**N66-13349\*#** h nu systems, inc., Palo Alto, Calif

**[DEVELOPMENT OF HIGH SPECIFIC POWER He-Ne LASERS] Final Report**

Richard S. Reynolds 29 Oct. 1965 50 p refs

(Contract NAS8-11613)

(NASA-CR-68589) CFSTI: HC \$3.00/MF \$0.50 CSCL 20E

This report covers the work performed in the development of two high specific power He-Ne lasers designed to operate in conjunction with optical tracking systems at 6328 Å only, with an objective of 50 mw single mode power output in a length of 50 cm maximum. The report discusses the areas of major study and indicates the areas of major accomplishments. Also discussed in detail are the areas requiring further refinements. Recommendations and conclusions based on the experience and results obtained are also listed.

Author

**N66-13536#** Institut Franco-Allemand de Recherches, St. Louis (France).

**SURVEY OF THE PRESENT SITUATION IN THE FIELD OF LASERS [ÜBERSICHT ÜBER DIE DERZEITIGE SITUATION AUF DEM LASERGEBIET]**

E. David 2 Oct. 1963 25 p In GERMAN  
(ISL-T-21/63) CFSTI: HC \$1.00/MF \$0.50

A brief review on the state-of-the-art for optical lasers is given. Theoretical analyses of causes and effects of stimulated light emission are described, construction principles and materials evaluated, and the modulation and application of lasers is discussed.

Transl. by G.G.

**N66-13744#** International Business Machines Corp., Yorktown Heights, N. Y. Watson Research Center.

**STUDIES ON HIGH POWER GaAs LASERS Final Technical Report, Jun. 1, 1963-May 31, 1965**

R S Title [1965] 60 p refs  
(Contract Nonr-4136(00); Proj. Defender)

(AD-621649) CFSTI: HC \$3.00/MF \$0.75

The report is a report on the studies of factors influencing the high power operation of GaAs injection laser diodes. The report deals specifically with aspects of GaAs crystal preparation, electrical and optical characterization of the material, and with the design, parameterization, and testing of GaAs injection laser diodes. Diodes have been operated at 77K with an energy output in excess of 0.001 joules during a 120 micron sec. pulse and with an external quantum efficiency of 18%.

TAB

**N66-13799#** Aeronutronic, Newport Beach, Calif.  
**CHEMICALLY PUMPED LASER SYSTEM First Quarterly Progress Report, 25 Jun. 1964-31 Jul. 1965**

S. Byron, W. Kuby, W. Lawrence, and R. V. Finizie 31 Aug. 1965 27 p refs

(Contract DA-36-034-AMC-0325(T))  
(U-3259; AD-622398) CFSTI: HC \$2.00/MF \$0.50

A summary is given of the state of the art in chemical pumping of lasers, the potential performance by various approaches is evaluated, and the specific approach chosen for further development under this contract is described. The program plan for the remainder of the contract is outlined and progress during the past quarter is described. During this quarter an experimental evaluation of various radiation coupling geometries and window materials led to a successful test in which laser action was produced in a ruby by shock heated xenon. A summary is also given of earlier studies by the Bio-Technology Department of the Philco C and E Division, Blue Bell, Pennsylvania, which were directed toward measuring eye damage in monkeys caused by laser irradiation. Author (TAB)

**N66-13913#** Sydney Univ. (Australia). School of Physics.  
**[PREIONIZATION AND SHOCK WAVE IONIZATION PROCESSES IN SUPPER I, ALFVEN WAVE STUDIES, CURRENT INDUCED INSTABILITY, A 2 mm INTERFEROMETER, AND LASERS] Ninth Six-Monthly Progress Report, 1 Jan.-30 Jun. 1965**

[1965] 7 p refs  
(NP-15355; PR-9) CFSTI: HC \$1.00/MF \$0.50

Progress is reported on preionization and shock wave ionization processes in SUPPER I, Alfven wave studies, current induced instability, a 2 mm interferometer, and lasers. NSA

**N66-14034#** Perkin-Elmer Corp., Norwalk, Conn. Electro-Optical Div.  
**RESEARCH TOWARD A TUNABLE COHERENT LIGHT SOURCE Final Technical Report, 1 May 1964-30 Apr. 1965**

Norman I. Adams 30 Jul. 1965 162 p refs  
(Contract Nonr-4572(00))

(Rept.-8071; AD-619530) CFSTI: HC \$5.00/MF \$1.00

The goal of the program is the development and demonstration of a tunable coherent light source based on nonlinear optical effects. An intermediate goal is the demonstration of parametric gain at optical frequencies. An apparatus was designed and constructed which is able to measure small gains or losses and which is named the 'Optical Marginal Oscillator.' The most recent version of the optical marginal oscillator is just about sensitive enough to measure the optical parametric effect expected in a specific experiment using two CW He-Ne lasers and crystal of ADP. A device, to produce a controlled loss of small magnitude was designed, built, and tested. The controlled loss may be made to be of the same size as the loss which is expected to be produced by the parametric effect in this experiment and has been used successfully to evaluate the marginal oscillator. Data were obtained on the performance of the optical marginal oscillator and on the dependence of its performance on the principal adjustable parameters, which are the oscillator light level and the modulation frequency. At the end of the current contract we are setting up the experiment to measure parametric gain.

TAB

**N66-14177#** General Telephone and Electronics Labs., Inc., Bayside, N. Y.

**CHELATE LASERS Annual Summary Report, 1 Oct. 1964-30 Sep. 1965**

A. Lempicki, H. Samelson, and C. Brecher 30 Oct. 1965 52 p refs

(Contract Nonr-4134(00); ARPA Order 306-62; Proj. Defender)  
(TR-65-052.11; AD-623264) CFSTI: HC \$3.00/MF \$0.50

The investigation of chelate lasers has as its objective the evaluation of the potentialities of liquid lasers and the analysis and improvement of their performance. Toward this end, the work was designed to proceed along two parallel and complementary lines: an investigation of the chemical properties of the materials, in terms of the requirements for laser action; and an investigation of the physical properties of the chelate laser itself, in terms of the design and improvement of the laser cavity and associated equipment. The report summarizes previous work and describes in detail the progress on these lines in the past year. A full-length paper entitled 'Spectroscopy and coordination chemistry of europium chelate solutions: concentration and solvent effects' is included as an appendix.

TAB

**N66-14188#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering

**DESIGN, CONSTRUCTION, AND STUDY OF A METAL TUBE ARII LASER**

Edward D. Aitken and John W. Dettmer (M.S. Thesis) Aug. 1965 73 p refs

(GE/EE/65-1; AD-623139) CFSTI: HC \$3.00/MF \$0.75

To provide a better method of cooling an argon ion laser, the arc-tube was constructed by alternately stacking 52 copper discs (1/8 in. long with a 3/32 in. hole in the center) and 53 viton O-rings. For this design the optimum fill-pressure was experimentally determined to be 0.24 torr and the voltage gradient in the arc-tube was 6.8 volts/cm. Over the discharge current range of 7.5 to 17.5 amperes, the power output varied as I<sup>3</sup> (3.5). By shorting groups of discs together, it was found that metal tube lasers can be constructed of segments with length-to-bore ratios of up to 11.33.

Author (TAB)

**N66-14191#** Illinois State Water Survey, Urbana.  
**EVALUATION OF THE MASER-EQUIPPED RADAR SET AN/MPS-34 AND AREA PRECIPITATION MEASUREMENT INDICATOR Quarterly Progress Report, 1 Apr.-30 Jun. 1965**

R. E. Rinehart and D. M. A. Jones [1965] 12 p  
(Contract DA-28-043-AMC-01257(E))  
(QPR-1; AD-623468) CFSTI: HC \$1.00/MF \$0.50

Problems encountered in the installation, operation, and repair of the MASER-equipped MPS-34 radar and Area Precipitation Measurement Indicator (APMI) are discussed. Both units are nearly ready for data collection. An outline is given for operations during the next quarter. Author (TAB)

**N66-14272#** Bell Telephone Labs., Inc., Murray Hill, N. J.  
**SOLID-STATE MASER RESEARCH (OPTICAL)** Quarterly  
**Progress Report, 14 Feb.-14 May 1965**

J. E. Geusic 14 May 1965 19 p refs  
(Contract DA-36-039-AMC-02333(E))  
(QR-7; AD-619706) CFSTI: HC \$1.00/MF \$0.50

The report presents work on the YAIG:Nd laser oscillator which relates to fundamental oscillator theory. It is experimentally verified that the YAIG:Nd oscillator is correctly described as a saturated regenerative amplifier of noise. Also presented in the report are some preliminary study results of the amplitude fluctuations of the YAIG:Nd laser. Author (TAB)

**N66-14355#** Joint Publications Research Service, Washington, D. C.

**TRANSLATIONS ON COMMUNIST CHINA'S SCIENCE AND TECHNOLOGY NO. 259**

9 Dec. 1965 18 p Transl. into ENGLISH from K'O-Hsueh Hua-Pao (Shanghai), no. 9, Sep. 1965 p 297-301  
(JPRS-33257; TT-65-33832) CFSTI: \$1.00  
CONTENTS:

1. PROGRESS IN LASER I-Min p 1-7
2. LASER APPLICATION K'o-Hua p 8-15

**N66-14467#** Massachusetts Inst. of Tech., Cambridge. Crystal Physics Lab.

**GROWTH AND STUDY OF CERTAIN PEROVSKITE-STRUCTURE LASER HOST CRYSTALS** Semiannual Status Report, Apr. 1-Oct. 1, 1965

A. Smakula et al. 22 Oct. 1965 12 p  
(Contract Nonr-3963(20))  
(AD-623511) CFSTI: HC \$1.00/MF \$0.50

Progress is described for work involving the crystal growth, lattice constant and density determination, and UV absorption edge measurement of magnesium potassium fluoride; and the flux growth and plasma torch growth of barium zirconate. TAB

**N66-14468#** Naval Air Engineering Center, Philadelphia, Pa.  
**FOUNDATIONAL RESEARCH PROGRAM**  
1965 219 p refs

(AD-623630) CFSTI: HC \$5.00/MF \$1.25

Progress is reported on twenty-six research projects. These include the following: *Fluid Mechanics; Lubrication of Metal Surfaces with Solid Films; Oxygen Embrittlement of Metals; Aircraft Ejection Seat Design; Salt Water Permeation through Organic Protective Coatings; High Strength Aluminum Alloy Corrosion; Biological Stress; Maser Spectroscopy; Air Bubble Test Vehicle; Jet Noise Suppression; Polarization Studies of Corrosion; Polymer Chemistry; Electron Microfractography; Metabolic Mechanisms of Man; Deep-Sea Simulation; Turbines; Radiation; Thermoplastics; Neutron Activation Analysis; Synthetic Fibers; Heat Transfer; Catapult Operations; Missile Launching; and Hydrogen Embrittlement of Metals and Alloys.* E.E.B.

**N66-14533#** Corning Glass Works, N. Y.  
**GLASS LASER RESEARCH** Semiannual Report, Dec. 1964-15 Jul. 1965

R. D. Maurer, M. E. Vance, G. E. Stong, N. F. Borrelli, S. D. Sims et al. 15 Aug. 1965 91 p refs  
(Contract Nonr-3833(00); Proj. Defender)  
(AD-623309) CFSTI: HC \$3.00/MF \$0.75

The report presents additional data on the properties of glass used in lasers as well as operating characteristics of glass lasers. The effect of intense ultraviolet radiation is shown to decrease the output of glass lasers much more than can be accounted for the decrease in fluorescence intensity or absorption of pump light. Comprehensive threshold and output data are given for several lasers of Code 0580 glass. These data can be approximately described by the theory of Miles and Goldstein using an internal oscillator loss only slightly higher than the measured static loss in the glass. Gain data of a glass laser amplifier show the difference between a glass laser probe and a narrow band probe with respect to averaging over the fluorescence line. Finally, quantitative measurements of the birefringence following pumping are given

Author (TAB)

**N66-14573#** Office of Naval Research, Washington, D. C.  
**LASER PHYSICS CONFERENCE**

Robert E. Behringer [1965] 96 p refs Conf. held Des Plaines, Ill., 22-23 Mar. 1965; sponsored jointly by ARPA  
(AD-622507) CFSTI: HC \$3.00/MF \$0.75

The Office of Naval Research sponsored an informal conference on fundamental problems in laser physics at the Concord Motel in Des Plaines, Illinois, on Monday and Tuesday, the 22nd and 23rd of March. The meeting was held primarily for the benefit of the ONR contractors receiving support from the Fundamental Limitations portion of the ONR/ARPA Laser Program. However, others interested in this aspect of the ONR/ARPA Laser Program were also invited to contribute to the meeting.

Author (TAB)

**N66-14591#** Edgerton, Germeshausen and Grier, Inc., Bedford, Mass.

**HIGH ENERGY LASER SYSTEM FOR GEODETIC RESEARCH** Final Report, 1 Apr. 1963-2 Jul. 1965

Sumner Ackerman 30 Sep. 1965 159 p refs  
(Contract AF 19(628)-2950)  
(B-3011; AFCRL-65-671; AD-622715) CFSTI: HC \$5.00/MF \$1.00

The design, operation, and performance of a high-energy laser system developed specifically for geodetic satellite research are described. The ground-based laser illuminator uses a liquid-N<sub>2</sub>-cooled 16-mm (diameter) by 184-mm (length) ruby crystal. It has a nominal output of 250 joules at 6935 Å with 17000 joules of pump supply and a pulse duration of 2.5 milliseconds. Discussion of the system's performance is based on 15 months of operating experience which has shown that high-energy lasers are practical for geodetic research applications requiring long periods of reliable operation under outdoor field conditions. The feasibility of Project LARGOS (Laser-Activated Reflecting Geodetic Optical Satellite), sponsored by the Terrestrial Sciences Laboratory of AFCRL, was verified experimentally using this equipment when clearly detectable star images of the Explorer 22 Satellite were obtained on 21 January, 29 January, and 3 February 1965 at ranges up to 925 statute miles. Range measurements by photoelectric detection were obtained simultaneously. A study was made of cube-corner reflectors suitable for satellite geodesy showing that, ideally, these should be almost diffraction limited with an aperture of the correct diameter to obtain the desired beamwidth. TAB

**N66-14672#** American Optical Co., Southbridge, Mass. Research Div.  
**PREPARATION OF PLATINUM-FREE LASER GLASS** Semiannual Technical Report, 1 Jan.-31 Jul. 1965

W. R. Pringle, G. A. Granitsas, and C. G. Silverberg [1965] 35 p ref  
(Contract Nonr-4656(00): ARPA Order 306-62; Proj. Defender)  
(SATR-2: AD-471803)

It was demonstrated that the oxidation of platinum followed by the subsequent reduction of the oxide particles to the metal is a major source of inclusions in laser glasses melted in systems containing platinum. These glasses can be melted in platinum without inclusions if an inert atmosphere such as nitrogen or argon replaces oxygen in the system. Laser glasses prepared in this manner have given excellent performance in high energy laser devices. In a parallel but different approach to the elimination of platinum inclusions an all-ceramic melting system has been designed and constructed. This system, which utilizes special refractories and stirring techniques, is undergoing preliminary tests. Author

**N66-14725#** Korad Corp., Santa Monica, Calif.  
**SOLID STATE LASER DEVICES**

R. H. Hoskins, R. C. Pastor, and I. M. Winer Sep. 1965 30 p refs

(Contract DA-36-039-AMC-00070(E))  
(QPR-9: AD-624164) CFSTI: HC \$2.00/MF \$0.50

Toward meeting the objective of developing a solid state laser with an output in the megawatt range and a repetition rate in the kilocycle range, studies have been conducted on a continuously-pumped Q-spoiled YAG:Nd<sup>3+</sup> laser. The results are reported here, along with an analysis of the behavior of such a system. Material studies on the systems Y<sub>2</sub>O<sub>3</sub>:Eu<sup>3+</sup> and YbAG:Er<sup>3+</sup> are also described. Author (TAB)

**N66-14801#** Aircraft Armaments, Inc., Cockeysville, Md.  
**RESEARCH ON THE ADAPTABILITY OF LASERS TO SCHLIEREN SYSTEMS Final Report**

John A. Ackerman and Gordon A. Brill, Jr. Wright-Patterson AFB, Ohio, ARL Jul. 1965 48 p  
(Contract AF 33(615)-1914)

(ARL-65-139: AD-622394) CFSTI: HC \$2.00/MF \$0.50

The purpose of the present contract was to develop and produce a laser source for the 10 inch schlieren system presently in use at the Fluid Dynamics Facilities Laboratory of ARL. The source, which uses a He-Ne Gas Laser for continuous viewing in conjunction with a Q-switched ruby source for taking very short exposure time photographs, has been developed and incorporated into the existing system. Certain problems still exist which greatly limit the overall system performance, but these are due to factors such as vibration, temperature fluctuations, and the quality of the existing optical system. Recommendations are made for the development of an overall system which will allow the potential of the laser source to be realized. Author (TAB)

**N66-14852#** New York Univ., N. Y. Geophysical Sciences Lab.  
**OPTICAL SOUNDING II, PART I. STUDY OF ACTIVE PROBING OF WATER VAPOR PROFILES AND RESULTS OF EXPERIMENTS Final Report, 6 Nov. 1963-15 Jul. 1965**

R. M. Schotland, D. Chang, and J. Bradley [1965] 100 p refs  
(Contract DA-36-039-AMC-03411(E))

(Rept.-65-6: AD-623513) CFSTI: HC \$3.00/MF \$0.75

A ruby laser system has been assembled which includes provision for thermally tuning the laser operating wavelength. Experiments have been carried out which were designed to test the potential of such a radar for the remote determination of the vertical profile of water vapor by means of spectral study of the back scattered energy. The results of the experiments indicate that such measurements are feasible. However, detailed information must be obtained on the water vapor absorption line structure. A theoretical study has been undertaken of the

contribution of secondary molecular scattering to the return observed by a laser optical radar. The results are presented as a function of the beam width of the receiver optics and the wavelength of the laser. It is shown that the contribution of secondary scatter to the observed energy can be made negligibly small by suitably restricting the beam width of the receiver optics.

Author (TAB)

**N66-14858#** Texas Instruments, Inc., Dallas.  
**LARGE-ANGLE DEFLECTION TECHNIQUES FOR LASER DISPLAY First Quarterly Report**

G. R. Fournier and H. W. Parker Griffiss AFB, N. Y., RADC, Nov. 1965 36 p

(Contract AF 30(602)-3731)

(U1-912008-1: RADC-TR-65-349; AD-624099) CFSTI: HC \$2.00/MF \$0.50

A large angle deflection technique for producing a 945-line T.V. type raster scan in an experimental laser display was developed, since conventional deflection methods could not be used. The horizontal scanner was comprised of a rotating mirror and a piezoelectric cartridge, coupled by a glass resonator shaft. A circular scan was generated and then transformed into a linear scan by a fiber optic converter. The use of the fiber optic bundle allowed zero flyback time. The linear beam was then deflected vertically by a galvanometer driven mirror at a 60 cycle per second rate. After vertical scanning, the light beam was projected through a lens on a screen. Circuitry for error sensing feedback for the scanners is continuing under study.

Author (TAB)

**N66-15042#** Joint Publications Research Service, Washington, D. C.

**TRANSLATIONS ON COMMUNIST CHINA'S SCIENCE AND TECHNOLOGY, NO. 253**

6 Dec. 1965 75 p refs Transl. into ENGLISH from Chinese periodicals

(JPRS-33152: TT-65-33728) CFSTI: \$3.00

#### CONTENTS:

1. MEDICAL FACILITIES THAT GUARD THE HEALTH OF SIX HUNDRED MILLION PEOPLE p 1-12

2. QUESTIONS AND ANSWERS ON COMMUNIST CHINA'S HEALTH INSURANCE p 13-16

3. RADIATION PROTECTION p 17-38 (See N66-15043 05-04)

4. POWER GENERATION BY SEA WAVES Mo p 39-40

5. OVERSEAS CHINESE UNIVERSITY IS DEVELOPING Chia-shen Yen p 41-43

6. ELECTROCHEMICAL STUDY ON CHEMICAL RATIO OF InSb L.-s. Yao and Y.-h. Tsou p 44-48 refs (See N66-15044 05-06)

7. OPTICAL MASER OF Nd<sup>3+</sup> IN CaWO<sub>4</sub> S.-f. Liu, C. Hsi, P.-k. Liang, Y.-k. Huang, S.-y. Li et al p 49-54 refs (See N66-15045 05-26)

8. COUPLING WAVE THEORY OF GUIDE WAVE PROPAGATION IN FERRITE CYLINDER WITH VARYING CROSS SECTION H.-c. Huang and T.-y. Fan p 55-58 (See N66-15046 05-23)

9. RESEARCH ON MICROPHYSICAL MECHANISM OF RAIN FROM WARM CLOUDS Hsiu-chi Chou p 59-64

**N66-15045** Joint Publications Research Service, Washington, D. C.

**OPTICAL MASER OF Nd<sup>3+</sup> IN CaWO<sub>4</sub>**

Shun-fu Liu, Ch-en Hsi, Pao-ken Liang, Yung-k'ai Huang, Shih-ying Li et al *In its* Transl. on Communist China's Sci. and Technol. 6 Dec. 1965 6 p refs Transl. into ENGLISH from K'o-Hsueh T'ung Pao (Peking), no. 9, 20 Sep. 1965 p 827-829 (See N66-15042 05-34) CFSTI: \$3.00

Crystals of  $\text{CaWO}_4$  containing trivalent neodymium were prepared in a platinum-rhodium crucible, annealed for eight hours at  $1,350^\circ\text{C}$ , and evaluated for their optical characteristics. C-axis crystals had a photon emission spectral line of 1.065 micrometers, and a-axis crystals had a 1.058 micrometer spectral line. Both showed the strongest emission line of 1.0651 micrometers at liquid nitrogen temperatures. Crystals of 3 to 5 mm diameter were made into Fabry-Perot optical frequency resonators for stimulated light experiments and their output energy data were obtained by radiation detector. Oscillograms for different energy inputs showed that neodymium ions in a tungstate crystal field produced a quadruple-energy level maser oscillation system of very good characteristics. G.G.

**N66-15048#** Joint Publications Research Service, Washington, D. C.

**TRANSLATIONS ON COMMUNIST CHINA'S SCIENCE AND TECHNOLOGY, NO. 261**

14 Dec. 1965 18 p refs Transl. into ENGLISH from Chinese periodicals (JPRS-33323; TT-65-33898) CFSTI: \$1.00

**CONTENTS:**

1. ON THE PHENOMENA OF MICROWAVE MASER BY LASER PUMPING W.-h. Huang, H.-y. Hsieh, Y.-s. Weing, and F.-c. Lin p 1-7 refs (See N66-15049 05-16)

2. THE FORMATION TIME OF OPTICAL OSCILLATION OF LASER H.-m. Teng, J.-w. Wang, and C.-l. Hsia p 8-11 (See N66-15050 05-16)

3. ANNOTATED TABLE OF CONTENTS OF CHINESE COMMUNIST JOURNAL ON GEOGRAPHY p 12-15

**N66-15049** Joint Publications Research Service, Washington, D. C.

**ON THE PHENOMENA OF MICROWAVE MASER BY LASER PUMPING**

Wu-han Huang, Hsiang-yen Hsieh, Yuan-shu Weing, and Fu-cheng Lin *In its* Transl. on Communist China's Sci. and Tech. 14 Dec. 1965 7 p refs Transl. into ENGLISH from K'o-hsueh T-ung Pao (Peking), no. 10, Oct. 1965 p 929-931 (See N66-15048 05-16) CFSTI: \$1.00

**N66-15050** Joint Publications Research Service, Washington, D. C.

**THE FORMATION TIME OF OPTICAL OSCILLATION OF LASER**

Hsi-ming Teng, Jun-wen Wang, and Cheng-li Hsia *In its* Transl. on Communist China's Sci. and Tech. 14 Dec. 1965 4 p Transl. into ENGLISH from K'o-Hsueh T-ung Pao (Peking), no. 10, Oct. 1965 p 931-932 (See N66-15048 05-16) CFSTI: \$1.00

A high speed rotating disk with equally spaced teeth around its edge was placed into a low temperature helium-neon laser cavity of known output and dimensions. The laser output signal was sent through the gaps in the disk, received by a photo-multiplier and displayed on an oscilloscope. An increase of the rotating disk speed reduced the output signal width correspondingly. Measurements of the rotation speed versus number of rotations at various frequencies were used to obtain the laser oscillation formation time. G.G.

**N66-15212#** Army Electronics Labs., Fort Monmouth, N. J. **DESIGN OF 15-Mc MICROELECTRONIC COUNTER FOR THE LASER RANGE FINDER**

George A. Hrivnak Dec. 1964 69 p (ECOM-2543; AD-624096) CFSTI: HC \$3.00/MF \$0.75

This report covers the design, fabrication and evaluation of a 15-Mc microelectronic laser range counter. The model which was developed measures only  $1\frac{1}{4}'' \times 3\frac{1}{4}'' \times 5''$

and weighs only 13 oz. It employs silicon integrated circuits, "chip and wire circuits" and micro-modules. It is completely maintainable, and provides full performance over the temperature range of  $+150^\circ\text{F}$  to  $-40^\circ\text{F}$ . The microelectronic laser range counter is operationally equivalent to the counter employed in the XE-6 laser range finder. A 66% size reduction and a 75% weight reduction were achieved. Author

**N66-15605#** Raytheon Co., Wayland, Mass. Advanced Development Lab.

**LASER PUMPING TECHNIQUES STUDY Final Report, 1 Oct. 1964-30 Sep. 1965**

Paul A. Silberg 30 Oct. 1965 72 p refs (Contract AF 49(638)-1420)

(AFOSR-65-2212; AD-623848) CFSTI: HC \$3.00/MF \$0.75

In the course of the study of laser pumping techniques, Raytheon developed a reliable calorimeter technique to measure the transfer efficiency of the  $\theta$  pinch in converting capacitively stored electrical energy to electromagnetic energy. It is shown, with the use of circuit measurements, that the efficient  $\theta$ -pinch circuit decay consists of a two-stage circuit decay and that the inefficient  $\theta$  pinch consists of a three-stage decay. Using the circuit decay data, a modified transfer efficiency measurement for a two-stage plasma circuit was developed that is approximately as accurate as the calorimeter technique, but very much faster and easier to make. These measurements have been used to evaluate the transfer efficiency of the  $\theta$ -pinch in Argon at pressures of 2 and 5 Torr with different tube sizes and with different coupling impedances. Measurements have shown a transfer efficiency as high as 59% with present measurements. Spectral measurements show that the preionization techniques increase the continuum radiation with the small diameter tubes and are ineffective with the largest diameter tubes used. Author (TAB)

**N66-15609#** Lincoln Lab., Mass. Inst. of Tech., Lexington. **SOLID STATE RESEARCH, 1 JANUARY-30 APRIL 1965**

Harry C. Gatos 22 Sep. 1965 109 p refs (Contract AF 19(628)-500)

(EDS-TDR-65-71; AD-622446)

This report covers in detail the solid state research work at Lincoln Laboratory for the period 1 January 1965 through 30 April 1965. The topics covered are Solid State Device Research, Laser Research, Materials Research, and Solid State Physics. TAB

**N66-15701#** American Optical Co., Southbridge, Mass. Research Div.

**EXCITED STATE SATURABLE ABSORBER FOR 1.06 MICRON WAVELENGTH Final Report, 4 Aug. 1964-6 Jul. 1965**

Charles C. Robinson Griffiss AFB, N. Y., RADC. Nov. 1965 66 p refs

(Contract AF 30(602)-3470)

(RADC-TR-65-369; AD-624361) CFSTI: HC \$3.00/MF \$0.75

The excited state absorption of a group of twenty glasses that were singly doped with fluorescent ions was investigated as a function of wavelength. Three ions  $\text{UO}_2^{2+}$ ,  $\text{Cu}^+$ , and  $\text{Er}^{3+}$  showed a strong effect and these ions were studied more extensively. Energy transfer between  $\text{Nd}^{3+}$ ,  $\text{Yb}^{3+}$ , and  $\text{Er}^{3+}$  was shown to increase the excited state absorption in  $\text{Er}^{3+}$ . Excited state saturable absorption was not observed for the 1.16 micron wavelength in either the  $\text{UO}_2^{2+}$  or the  $\text{Cu}^+$  glass. These last experiments were not extensive enough to be conclusive. Author (TAB)

**N66-15720#** Cutler-Hammer, Inc., Deer Park, N. Y. Airborne Instruments Lab.

**STUDY OF SOLID-STATE AND TRAVELING-WAVE MASER TECHNIQUES**

J. A. De Gruyl, W. W. Heinz, S. Okwit, and J. G. Smith Griffiss AFB, N. Y., RADC, Nov. 1965 30 p refs  
(Contract AF 30(602)-2989)

(RADC-TR-65-366; AD-624359) CFSTI: HC \$2.00/MF \$0.50

The purpose of this program is to develop improved maser techniques and apply them to a broad-band maser system. The deliverable breadboard maser system has been fabricated, assembled, and initial testing has been completed. The unit basically provided gains of 30 db over 260 Mc of instantaneous bandwidth at 2.1 k. This inherent bandwidth far exceeds that obtained in any other maser known to date. Continued performance testing and limited modifications to the system are being made during the final phase of the program. An extension in time has been requested to enable this work to be completed. The semiconductor device program has been completed. This work has resulted in the development of techniques for limiting as well as modulating microwave signals. The results were presented at the recent PGMTT symposium in Clearwater, Florida.

Author (TAB)

**N66-15966#** Ohio State Univ. Research Foundation, Columbus. Antenna Lab.

**NOISE IN AN OPTICAL HOMODYNE SYSTEM**

Marvin E. Monroe 1 Oct. 1965 115 p refs

(Contract AF 33(615)-2287)

(Rept.-1935-7; AD-474465)

This report contains the derivations necessary to express the functional dependence of the output of an optical homodyne system including signal and noise terms. The experimental work gives evidence of the validity of these expressions and indicates the order of magnitude of the different effects.

Author (TAB)

**N66-16086#** Wheeler Labs., Inc., Great Neck, N. Y.  
**DEVELOPMENT OF MACROSCOPIC WAVEGUIDE AND WAVEGUIDE COMPONENTS FOR OPTICAL SYSTEMS**  
Final Report, 28 Jan.-28 Nov. 1964

E. R. Schineller, H. M. Heinemann, D. W. Wilmot, and H. W. Redlien Washington, NASA, Jan. 1966 144 p refs  
(Contract NAS12-2)

(NASA-CR-332) CFSTI: HC \$5.00/MF \$1.00 CSCL 20E

The design, development, and fabrication of macroscopic waveguide and waveguide components for optical systems which operate in a single spatial mode, are discussed. Feasibility tests were performed on the various waveguide configurations, and results indicate that macroscopic optical waveguides and components are feasible in operation and construction; and that the concept offers promise of high performance components for sophisticated laser systems. L.S.

**N66-16210#** Westinghouse Electric Corp., Baltimore, Md. Aerospace Applied Physics Group.

**DEVELOPMENT OF MILLIMETER AND SUBMILLIMETER MASER DEVICES** Interim Report No. 8, 1 Jul.-31 Oct. 1965

W. E. Hughes and C. R. Kremenek Nov. 1965 21 p refs

(Contract AF 33(657)-10472)

(Rept.-490H; AD-623807) CFSTI: HC \$1.00/MF \$0.50

The investigation of an iron ( $\text{Fe}^{3+}$ ) doped rutile zero field maser amplifier was completed. Further investigations of this device will be conceived with its characteristics as a solid-state oscillator. Experiments to develop a 94-gHz push-pull maser were conducted during this period; however, it was not possible to produce significant net gain because of a lack of sufficient pumping power. Investigation of X-band zero

field masers was continued during this period using polycrystalline iron-doped aluminum chloride.

Author (TAB)

**N66-16411#** Hughes Research Labs., Malibu, Calif.

**DISPERSION EFFECTS IN LASER AMPLIFIERS** Final Scientific Report, 1 Oct. 1964-30 Sep. 1965

George F. Smith, Wilbur P. Brown, Jr., and Concetto R. Giuliano [1965] 108 p refs

(Contract AF 49(638)-1439)

(AFOSR-65-2211; AD-623849) CFSTI: HC \$4.00/MF \$0.75

It has been shown that the Rytov approximation is severely limited in its applicability to long distance optical propagation in the atmosphere. A new and powerful boundary layer calculational technique has been developed and applied to the problem of scattering of electromagnetic waves from convex cylinders near grazing incidence. Multigigacycle acoustic waves were generated in crystalline solids by giant pulse ruby laser radiation; several unsuccessful attempts were made to probe these waves with Bragg-scattered gas laser radiation. However, multiple wavelength shifts in stimulated Brillouin scattering from quartz were observed; it was established, by time resolved interferometry, that these shifts result from an iterative process.

Author (TAB)

**N66-16473#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

**A CONCEPTUAL MODEL OF THE BACK-SCATTERED FIELD OF LASERS AND THE USE OF THAT MODEL FOR ROTATION DETECTION**

Edward Phillip Martin and Robert Ray Sipes (M.S. Thesis, Air Univ.) Aug. 1965 80 p refs

(GE/EE/65-13; AD-622425) CFSTI: HC \$3.00/MF \$0.75

With the use of a laser, it is possible to measure rotation of a remote object by two techniques: Rotation can be measured by the laser back-scattered field technique and the Doppler spectrum technique. The motion of the back-scattered field was investigated and found to be related to the motion of the target surface. A surface model was developed for the explanation of all experiments performed on the back-scattered field. From preliminary work on the Doppler spectrum, two side results were obtained: (1) a method was discovered to heterodyne the Doppler signal without an external interferometer and (2) a method to measure rotation by the Staas effect (AD-608 087) was demonstrated. Work on the Doppler technique was not completed because of variations in the target speed.

Author (TAB)

**N66-16656#** Rochester Univ., N. Y. Inst. of Optics.

**TIME RESOLVED SPECTROSCOPY AND INTERFEROMETRY ON LASER RODS, APPENDIX I AND II** Final Report, 1 Sep. 1962-30 Nov. 1964

Michael M. Hercher Jun. 1965 136 p refs

(Contract AF 19(628)-2360)

(AFCLR-65-467; AD-620185) CFSTI: HC \$4.00/MF \$1.00

**CONTENTS:**

1. TIME RESOLVED SPECTROSCOPY AND INTERFEROMETRY ON LASER RODS. APPENDIX I: [HIGH SPEED PHOTOGRAPHY AND INTERFEROMETRY ON LASER RODS] Final Report, 1 Sep. 1962-30 Nov. 1964 M. M. Hercher 33 p refs (See N66-16657 07-16)

2. TIME RESOLVED SPECTROSCOPY AND INTERFEROMETRY ON LASER RODS. APPENDIX II: A STUDY OF THE EMISSION FROM A TRAVELING WAVE RUBY LASER Final Report, 1 Sep. 1962-30 Nov. 1964 C. B. Smoyer 99 p refs (See N66-16658 07-16)

**N66-16657#** Rochester Univ., N. Y. Inst. of Optics.  
**TIME RESOLVED SPECTROSCOPY AND INTERFEROMETRY ON LASER RODS. APPENDIX I: [HIGH SPEED PHOTOGRAPHY AND INTERFEROMETRY ON LASER RODS]** Final Report, 1 Sep. 1962-30 Nov. 1964

Michael M. Hercher *In its* Time Resolved Spectry. and Interferometry on Laser Rods Jun. 1965 33 p refs (See N66-16656 07-16) CFSTI: HC \$4.00/MF \$1.00

This report describes investigations carried out on solid state laser phenomena in two different areas. (1) High speed photography of near field phenomena in the radiation from several ruby lasers shows quite clearly the very complex distribution of intensity both in space across the face of the ruby and in time (spiking). (2) Time resolved interferometry has been carried out on laser rods under pump conditions, but without lasing, to observe effects of heating by the pump radiation. An important feature of these observations is a temporary distortion of the optical path through the outer portions of the laser rod, requiring a recovery time of several seconds for glass and a fraction of a second for ruby. Author

**N66-16658** Rochester Univ., N. Y. Inst. of Optics.  
**TIME RESOLVED SPECTROSCOPY AND INTERFEROMETRY ON LASER RODS. APPENDIX II: A STUDY OF THE EMISSION FROM A TRAVELING WAVE RUBY LASER** Final Report, 1 Sep. 1962-30 Nov. 1964

Claude Benzing Smoyer (M.S. Thesis) *In its* Time Resolved Spectry. and Interferometry on Laser Rods Jun. 1965 99 p refs (See N66-16656 07-16) CFSTI: HC \$4.00/MF \$1.00

Evidence of spectral narrowing in the output of a traveling wave ruby laser is presented. A comparison of equivalent traveling and standing wave cavities shows that for similar excitation, spectral narrowing of better than a factor of four can be achieved. However, multimoding in this experimental arrangement is still strongly evident. Results of preliminary experiments in Q switching the traveling wave cavity are also presented. These results are inconclusive, but do show the need for a more sophisticated experimental procedure for obtaining optimum results from a Q switched traveling wave laser cavity. Author

**N66-16740#** Stanford Univ., Calif. Microwave Lab.  
**LASER MATERIAL (SPECTROSCOPY)** Semiannual Report No. 1, Dec. 15, 1964-Jun. 15, 1965  
 Jul. 1965 132 p refs  
 (Contract DA-28-043-AMC-00446(E))  
 (ML-1346; AD-621488) CFSTI: HC \$4.00/MF \$1.00

**CONTENTS:**

1. LUMINESCENCE IN RARE EARTH MATERIALS p 1-33 refs (See N66-16741 07-26)
2. SPECTRAL CHARACTERISTICS OF LASER OSCILLATORS p 34-118 refs (See N66-16742 07-16)

**N66-16741** Stanford Univ., Calif. Microwave Lab.  
**LUMINESCENCE IN RARE EARTH MATERIALS**  
*In its* Laser Mater. (Spectry.) Jul. 1965 p 1-33 refs (See N66-16740 07-26) CFSTI: HC \$4.00/MF \$1.00

The line structure of the photoluminescence of ZnS:Tb, ZnS:Nd, ZnS:Tm and ZnS:Dy has been studied under various preparative conditions. There is a strong tendency for rare earth pairing with other lattice defects in the presence of excess S. This pairing is manifested by the appearance of new emission and excitation bands. Of the many distinct sites for the rare earth ion, one seems to stand out as most important in electroluminescence although it gives only a minor contribution to the photoluminescence. Using a variety of luminescent phenomena, we are able to count at least four distinct

sites for trivalent rare earth ions in ZnS and there is strong evidence that more exist. Preparation of CdS:Nd has been achieved so that reasonably strong Nd<sup>3+</sup> emission is obtained. A multiplicity of Nd<sup>3+</sup> sites is evident. Emission of CdS:Er has also been observed. Tunnel injecting contacts have been formed on slices of a single crystal of CdS:Nd.

Author

**N66-16742** Stanford Univ., Calif. Microwave Lab.  
**SPECTRAL CHARACTERISTICS OF LASER OSCILLATORS**  
*In its* Laser Mater. (Spectry.) Jul. 1965 p 34-118 refs (See N66-16740 07-26) CFSTI: HC \$4.00/MF \$1.00

A review and synthesis of the previous literature on oscillator spectra, with particular emphasis on laser oscillators, is presented. The below-threshold oscillation spectral width,  $\Delta f_{osc}$ , is derived:

$$\Delta f_{osc} = \frac{2\pi kT \Delta f^2}{P_{osc}}$$

where  $\Delta f$ =bandwidth of the passive circuit without the negative conductance,  $P_{osc}$ =total noise power output from the oscillator. The above-threshold oscillation spectral width due to phase fluctuations in the oscillator output is

$$\Delta f_{osc, PM} = \frac{\pi kT \Delta f^2}{P_{osc}}$$

The above-threshold spectral width due to amplitude fluctuations (the AM contribution to the spectral width) is  $\Delta f_{AM} = G_1/2\pi C$ , where  $G_1$  is an equivalent conductance defined in the report. A practical Nd:YAG CW laser system has been designed and built. An aluminized glass, cylindrical cavity was used, and a linear tungsten filament, ASA-DXN 1000 watt lamp was used as an optical pump. The laser threshold was between 900 and 1000 watts. Author

**N66-16745#** Lincoln Lab., Mass. Inst. of Tech., Lexington.  
**SOLID STATE RESEARCH, 1 May-31 July 1965**  
 4 Nov. 1965 87 p refs  
 (Contract AF 19(628)-5167)

(ESD-TDR-65-318; AD-624611) CFSTI: HC \$3.00/MF \$0.75  
 The report covers in detail the solid state research work at Lincoln Laboratory for the period 1 May 1965 through 31 July 1965. The topics covered are Solid State Device Research, Laser Research, Materials Research, and Physics of Solids. Author (TAB)

**N66-16806#** Joint Publications Research Service, Washington, D. C.  
**TRANSLATIONS OF COMMUNIST CHINA'S SCIENCE AND TECHNOLOGY, NO. 278**  
 17 Jan. 1966 217 p refs Transl. into ENGLISH from K'o Hsueh T'ung-Pao (Peking), no. 11, 1965 p 941-1034  
 (JPRS-33759; TT-66-30202) CFSTI: \$6.00

**CONTENTS:**

1. TOTAL SYNTHESIS OF CRYSTALLINE OX INSULIN Yueh-T'ing Kung, Yu-ts'ang Tu, Wei-te Huang, Ch'ang-ch'ing Ch'en, Lin-chun Ko et al p 1-11 refs
2. RESEARCH ON SOLAR ACTIVITIES Ch'en Piao p 12-19 refs (See N66-16807 07-29)
3. CURRENT CONDITIONS OF THE STUDY OF GEOMECHANICS T.-c. Sun and C.-h. Chen p 20-38 ref (See N66-16808 07-13)
4. HYDROLOGICAL STUDY OF ARID REGIONS IN CHINA'S NORTHWEST AND VIEWS FOR FUTURE STUDIES p 39-55 refs

5. SEVERAL PROBLEMS CONCERNING THE PHYSIOLOGICAL MECHANISM OF MEMORY Jih-ch'ang Ts'ao p 56-63 refs

6. PROBLEM OF SINGLE WEATHER STATION TO REPORT LOCATION OF THUNDER LIGHTNING ACTIVITIES C.-c. Ku p 64-72 refs (See N66-16809 07-20)

7. DEVELOPMENTS IN RESEARCH ON SB-58 TREATMENT OF SCHISTOSOMIASIS JAPONICA Jih-kuang Hsu and Ming-kang Ch'ien p 73-89 refs

8. MICROCRYSTALLINE GLASS C.-c. Li p 90-103 refs (See N66-16810 07-18)

9. THE CATALYSTS BASED ON TITANIUM TETRAN-BUTOXIDE TO POLYMERIZE BUTADIENE INTO POLYMER WITH CIS-1.4 CONFIGURATION Hung-ch'uan Hsieh and Chiu-mien Wen p 104-112 refs

10. ULTRAPURIFICATION DISTILLATION C.-f. Fu p 113-126 refs (See N66-16811 07-06)

11. SPECTROPHOTOMETRIC MEASUREMENT OF NIOBIUM IN ARSENIC TETRAPHENOL-NIOBIUM SULFOCYANATE Ju-ch'in Yu, Hsien-ting Huang, and Fei-chi Ho p 127-128 refs

12. DISCOVERY OF A NEW VARIETY OF DRAVITE AND ITS SIGNIFICANCE FOR MINERALOGY Hsiu-chang Wang and Hsueh-yen Hsu p 129-137 refs

13. TRANSMISSION CHARACTERISTICS OF THE ND<sup>3+</sup> LASER F.-h. Kan, Y.-s. Ts'ai, C.-h. Chiang, H.-s. Li, and C.-f. Li p 138-151 refs (See N66-16812 07-16)

14. ELECTRON TEMPERATURE AND DENSITY INSIDE A GAS DISCHARGE TUBE C.-c. Lin, H.-h. Ch'ien, and Y.-s. Tang p 152-160 refs (See N66-16813 07-25)

15. SYMPOSIUM ON SALINE SOIL IMPROVEMENT Wan-yun Ho p 161-166

16. CENTRAL CHINA ORCHARD AND YOUNG TREE EXPERIMENTAL FARM WORKING CONFERENCE Chieh-p'ing Hu and Tun-hsien Liu p 167-169

17. FOURTH SESSION OF THE ALL-CHINA COMPUTATION TECHNIQUES EXPERIENCE EXCHANGE CONFERENCE Shao-tsung Ho p 170-173

18. UTILIZATION OF INDUSTRIAL DISCARDS TO MANUFACTURE NEW CONSTRUCTION MATERIALS Ch'eng-tsu Ch'u p 174-181

19. SECOND ALL-CHINA GLASS FIBER SYMPOSIUM p 182-187

20. THE THIRD ALL-CHINA EAR, NOSE AND THROAT SYMPOSIUM Tang Chien p 188-190

21. BRIEF NEWS REPORTS ON ACADEMIC CONFERENCES p 191-193

22. BOOK REVIEWS p 194-199

**N66-16812** Joint Publications Research Service, Washington, D. C.

# **TRANSMISSION CHARACTERISTICS OF THE ND<sup>3+</sup> LASER**

Fu-Hsi Kan, Ying-Shih Ts'ai, Chung-Hung Chiang, Hsi-Shan Li, and Ch'eng-Fu Li *In its* Transl. on Communist China's Sci. and Technol. 17 Jan. 1966 p 138-151 refs (See N66-16806 07-34) CFSTI: \$6.00

An aluminum glass laser was studied for its transmission spectrum and oscillating characteristics. Nd<sup>3+</sup> ion density, glass composition and uniformity and their influences on resonance reflectivity and output energy, and finally the characteristics of the glass laser. Measurements of the width of the excited spectrum established its dependence on the output energy; excited laser transmission was composed of many small pulses, with the pulse density inversely proportional to the oscillating time. A comparison of seven different silicon salt glasses of different ion densities showed that at low densities the Nd<sub>2</sub>O<sub>3</sub> composition increased, but quantum efficiency and fluorescent life time did not change much. At high

density, quantum efficiency and fluorescent life time decreased noticeably. The long life time of silicon salted glasses, and the spectrum width of boric salted glasses were found superior to aluminum phosphate salted glasses for their transmitting parameters. G.G.

**N66-16824#** Linde Div., Union Carbide Corp., Indianapolis, Ind. Speedway Labs.

# **SYMMETRICAL LASER CRYSTALS Final Technical Report, 1 May 1963-31 Oct. 1965**

O. H. Nestor 30 Nov. 1965 75 p refs  
(Contract Nonr-4131(00); ARPA Order 306-62)  
(SRCR-65-9; AD-624514) CFSTI: HC \$3.00/MF \$0.75

The development of cubic perovskites as symmetric hosts for laser dopant ions is of interest because long fluorescent lifetimes are to be expected. Other work on LaAlO<sub>3</sub>:Cr appears to confirm this. The simple II-IV perovskites are of interest as hosts for divalent and tetravalent dopants, but only four such compounds SrTiO<sub>3</sub>, SrSnO<sub>3</sub>, BaSnO<sub>3</sub> and BaZrO<sub>3</sub> are known to be cubic at room temperature. The low dielectric properties and stability toward reduction of BaZrO<sub>3</sub> makes it the most attractive potential host. The refractory nature of this compound has heretofore prohibited melt synthesis of single crystal BaZrO<sub>3</sub>. A novel crucible-less melting technique, referred to as skull-melting, was studied intensively as a means for producing single crystals of BaZrO<sub>3</sub> (and SrTiO<sub>3</sub>). The process involves inductive coupling of electromagnetic radiation directly to the melt which acts as its own susceptor. The effects of many of the numerous variables, both thermal and electrical, on the process were studied. The coupling of energy is found to depend primarily on the frequency and the size and electrical conductivity of the melt. Numerous experiments demonstrated that SrTiO<sub>3</sub> (and BaTiO<sub>3</sub>) may be fused by this process in a nearly reproducible manner and maintained in the molten state apparently indefinitely. Many attempts were made to pull single crystals of SrTiO<sub>3</sub> (and BaTiO<sub>3</sub>) but only dark, polycrystalline masses of partially deoxidized material were obtained. TAB

**N66-16967#** College of William and Mary, Williamsburg, Va.  
**MEASUREMENT OF LIGHT SCATTERED FROM A LASER BEAM BY THE ATMOSPHERE Semiannual Status Report No. 3, Jun. 1-Nov. 30, 1965**

James D. Lawrence, Jr. [1965] 16 p  
(Grant NSG-710)

(NASA-CR-70177) CFSTI: HC \$1.00/MF \$0.50 CSCL 20E

A workable laser system was delivered, and a number of backscatter measurements made. The observations made to date have been made with the laser system operating at about 20% efficiency and with neutral density filters (attenuation factor: about 100) ahead of the receiving optics. Even so excellent backscatter observations of the lower atmosphere to about 30 km have been made and clearly indicate the aerosol structure of the lower atmosphere. Several examples of these measurements are included in this report. In addition, theoretical analysis of the problem is proceeding. Author

**N66-17001#** General Precision, Inc., Pleasantville, N. Y. Aerospace Group.

# **PUMPED TRANSFORMER LASERS Technical Summary Report No. 2, 1 May-1 Nov. 1965**

Cecil B. Ellis, James H. Simpson, and Donald S. Bayley 22 Nov. 1965 85 p refs  
(Contract Nonr-4718(00); ARPA Order 306; Proj. Defender)  
(GPL-A-31-2; AD-624481) CFSTI: HC \$3.00/MF \$0.75

Most of the analysis in this period has dealt with use of metastable nitrogen molecules as the active medium for a transformer laser to be pumped by a battery of Nd glass auxiliary lasers. It was concluded that such a medium would be



operable, but that adequate data are not at hand to produce optimism on reaching maximum output pulse energy densities in the nitrogen greater than the region of one joule/cc. with satisfactory maintenance of optical beam quality. An extension of previous analysis on a similar use of  $\text{CN}$  molecules indicates that this medium might be expected to yield satisfactory outputs around one joule/cc or somewhat greater. From the meager information available today, it appears that diatomic cesium molecules might possibly surpass  $\text{CN}$  and constitute the best medium for transformer action with Nd glass laser pumping. An experimental attack on some of the many remaining unknowns regarding  $\text{Cs}_2$  is now underway, and first preliminary tests are reported. A beginning has been made toward mathematical spatial analysis of the higher power flux patterns to be expected within a heavily pumped transformer medium. Author

**N66-17007#** Perkin-Elmer Corp., Norwalk, Conn. Electro-Optical Div.

**CRYSTALS FOR OPTICAL MASER APPLICATIONS Second Quarterly Progress Report, 1 May-31 Jul. 1965**

J. B. Schroeder and J. F. Nester 31 Aug. 1965 34 p refs /Its Rept-2

(Contract DA-28-043-AMC-00474(E))

(PE-TR-8110; AD-624558) CFSTI: HC \$2.00/MF \$0.50

This paper contains a discussion of experimental annealing techniques designed to relieve mechanical strain within  $\text{Gd}_3\text{Ga}_5\text{O}_{12}$  crystals. In addition, the techniques and data used for the measurement of excitation spectra, fluorescent lifetimes, large-angle scattering, and fluorescence linewidths for several neodymium-doped glasses are discussed. The analysis of data taken for the room-temperature ruby  $R_1$  linewidth revealed instrument broadening effects, and various approaches to this measurement were examined. This report also mentions an optical walkie-talkie device, but details of the work on this instrument are deferred to a later report. Descriptions of the various optical components fabricated and delivered to the customer during the second quarter are also included. Plans for experimental work to be conducted during the next quarter are given. Author (TAB)

**N66-17234\*#** National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.  
**10.6 MICRON COMMUNICATION SYSTEM**

Nelson Mc Avoy Nov. 1965 26 p refs

(NASA-TM-X-55396; X-524-65-461) CFSTI: HC \$2.00/MF \$0.50 CSCL 17B

Based on an analysis of existing operable equipment, or equipment which will shortly be available, it is proposed that the 10.6 micron wavelength be adopted for deep space laser communication systems. The mathematics are briefly outlined which show that with existing optical receivers the minimum detectable power signal cannot be achieved in the radio frequency microwave or millimeter ranges. Next, practical telescope apertures, laser transmitter antenna gains, and practical limitations of pointing transmitters are considered; and it is suggested that the aperture for existing infrared diffraction limited telescopes be not less than one meter. Further, it is shown that the lowest laser frequency which may be used with a one meter aperture is in the 10 micron region. Also discussed are (1) atmospheric absorption and scatter; (2) atmospheric distortion of the plane isophase surface of the transmitted beam; and (3) Doppler shift of the transmitted beam and its effects on reception. Finally, a complete set of parameters is proffered for a telemetry link between a Mars borne laser probe and receivers on the Earth. D.T.

**N66-17291\*#** General Telephone and Electronics Lab., Inc., Bayside, N. Y.

**INVESTIGATION OF ELECTRO-OPTICAL TECHNIQUES FOR CONTROLLING THE DIRECTION OF A LASER BEAM. PART ONE: BEAM DEFLECTOR DEVICES. PART TWO: BEAM DEFLECTOR SYSTEMS Interim Report**

V. J. Fowler, J. Schlafer, S. Kapuscinski, R. Johnson, and P. Weiss 29 Mar. 1965 76 p refs

(Contract NAS8-11459)

(NASA-CR-68895; TR-65-722.8) CFSTI: HC \$3.00/MF \$0.75 CSCL 20E

An investigation of a system for optical acquisition and tracking is described. Part I of the report is concerned with the experimental development of the key component of the system, a laser beam steerer which uses piezoelectrically driven mirrors. Consideration is given to maximum attainable resolution, frequency response, hysteresis, thermal and aging effects, and unwanted modes of deflection. Part II deals mainly with the theoretical aspects of the system. This section discusses types of scan modes, range calculations, and noise analysis including combined effects of atmospheric and shot noise. Also described are results of a one dimensional tracking system incorporating shear plate deflectors. Author

**N66-17320\*#** Columbia Univ., New York. Radiation Lab.  
**RESEARCH INVESTIGATION DIRECTED TOWARD EXTENDING THE USEFUL RANGE OF THE ELECTROMAGNETIC SPECTRUM Third Quarterly Progress Report, Jun. 16-Sep. 15, 1965**

R. Novick 15 Sep. 1965 82 p refs /Its Progr. Rept. No. 11 (Grants NSG-360; NSG-442; DA-ARO(D)-31-124-G568; NSF GP-1031; Contract DA-28-043-AMC-00099(E))

(NASA-CR-70391) CFSTI: HC \$3.00/MF \$0.75 CSCL 20H

Numerous studies are underway in order to extend the useful range of the electromagnetic spectrum, and progress is reported for projects dealing with atomic, molecular, and solid state physics; properties of radioactive atoms; optical and microwave masers; and radio and X-ray astronomy. Under many experimental conditions, the decay of an ensemble of excited atoms is characterized by several relaxation times. Radiation due to the impact of very slow helium ions on the rare gases has been observed. In at least one instance this radiation results from charge exchange with simultaneous excitation. A new optical system is reported which uses a lensless geometry and can define scattering angles at accuracies better than  $\pm 10'$  of arc without any averaging effects of a collecting lens. M.W.R.

**N66-17361#** Harry Diamond Labs., Washington, D. C.  
**AN OPTICAL SURFACE DISCRIMINATOR**

William L. Soper 31 Aug. 1965 10p

(HDL-TM-65-41; AD-624286) CFSTI: HC \$1.00/MF \$0.50

An apparatus has been designed and build for the purpose of discriminating between reflecting and nonreflecting surfaces for optical radiation in the near infrared. The design and performance of the apparatus are discussed. Author (TAB)

**N66-17604#** Naval Research Lab., Washington, D. C.  
**AN ATLAS OF THE ABSORPTION OF THE ATMOSPHERE FROM 8512 TO 11,600A**

J. A. Curcio, R. Eckardt, C. V. Acton, and T. H. Cosden 15 Oct. 1965 29 p refs

(NRL-6352; AD-624323) CFSTI: HC \$2.00/MF \$0.50

This report presents an atlas of the atmospheric spectral absorption structure of a 10.1-mile sea level path when the atmosphere contained 4.5 cm of precipitable water and when the atmosphere contained 12 cm of precipitable water. A neodymium glass laser spectrum is also included and shown

to emit in a spectral region which is particularly free of atmospheric absorption. Author (TAB)

**N66-17721\*** Perkin-Elmer Corp., Norwalk, Conn. Electro-Optical Div.

**EFFECTS OF AEROSPACE TECHNOLOGY ON CIVILIAN LIFE THROUGH SCIENTIFIC INSTRUMENTATION**

John G. Atwood *In* NASA. Marshall Space Flight Center (See N66-1770608-15) GPO: HC \$1.50; CFSTI: MF \$1.25

The development and production of scientific instruments for industrial, medical, and educational use is closely associated with, and affected by the national aerospace program. Part of the effect comes directly through the aerospace support of technology actually used in instruments, such as electro-optics. Part comes from requirements of the instrumentation industry to develop new instrument systems of extraordinary performance to meet special aerospace needs. This knowledge and technology becomes available to other users through commercial instrumentation which later embodies it. A realistic discussion of how this transfer comes about cannot be carried on only by recitation of individual examples, although many interesting ones exist. Rather, the large scale economic factors are to be considered such as the effect which demands of the aerospace industries have on the technical capital equipment industry. Tracing these effects on the technical capital equipment available to civilian industry, education, and medicine completes the cycle. The depth to which familiar aspects of our daily lives have become dependent on a highly advanced and expanding civilian technology is revealed in this process.

Author

**N66-17933#** National Research Council of Canada, Ottawa (Ontario).

**ESTIMATION OF HEATING OF A PLASMA BY LASERS [ABSCHATZUNGEN ZUR AUFHEIZUNG EINES PLASMAS MITTELS LASERN]**

H. Hora 1965 22 p refs Transl. into ENGLISH from Rept. IPP/6/23, Inst. für Plasmaphysik, Univ. Frankfurt (West Germany), 1964 14 p

(NRC-TT-1193) CFSTI: HC \$2.60/MF \$0.86

Earlier estimations of whether plasmas can be heated with brief laser impulses to temperatures which are of interest with respect to thermonuclear conditions are continued from the point of view that the high light field intensities produce a non-resonant ionization. Depending on whether the duration of this process is comparable with, or much greater than, the period of vibration of the light, some rough estimates are made of the extent to which a more favorable heating can be achieved with the greater densities that are then very probably attainable. In making these estimates the optical constants are explicitly computed for the hydrogen plasma, and the earlier results of Engelhardt are improved by numerical methods.

Author

**N66-18135#** Joint Publications Research Service, Washington, D. C.

**PHYSICAL PROBLEMS OF QUANTUM ELECTRONICS**

A. N. Orayevskiy 23 Feb. 1966 10 p Transl. into ENGLISH from Vestn. Akad. Nauk SSSR (Moscow), no. 12, Dec. 1965 p 47-50

(JPRS-34262; TT-66-30703) CFSTI: \$1.00

Some fundamental aspects of research discussed at a conference on physical problems of quantum electronics are presented. Included are discussions of nonlinear optical phenomena, including combination scattering and Mendel'shtam-Brillouin scattering; semiconductor lasers; gas discharges in gas lasers; gas breakdown in the focus of a laser beam; and general theoretical problems.

R.N.A.

**N66-18174\*** Radio Corp. of America, Camden, N. J.  
**AN INVESTIGATION OF SUPERCONDUCTIVE TECHNIQUES FOR BROADBAND TRAVELING-WAVE MASERS**  
Washington, NASA, Mar. 1966 40 p refs  
(Contract NAS5-3773)

(NASA-CR-386) CFSTI: HC \$2.00/MF \$0.50 CSCL 20E

Research conducted with multicore superconducting magnets capable of operating with traveling wave masers is described. The experimental work performed was confined to double- and triple-field stagger tuning of a rutile meander line traveling wave maser; these measurements are compared with the theory for broadbanding traveling wave masers. A technique for obtaining extremely wide bandwidth (120 Mc) in masers is presented. As a result of this project, traveling wave masers with bandwidths exceeding 200 Mc may be developed immediately, using presently available materials and techniques. It is also shown that experimental traveling wave masers capable of trading gain for bandwidth electronically may be designed. Since the theory of magnetic stagger tuning for increased bandwidth has been established, it is recommended that continued research be conducted in the areas of improved rutile crystal performance and optimum loadings of the meander line rutile maser. All indications point to traveling wave maser bandwidths of 20 percent to be fully realizable in the near future.

Author

**N66-18228#** Los Alamos Scientific Lab., N. Mex.  
**HIGH TEMPERATURE THERMAL DIFFUSIVITY MEASUREMENTS BY THE FLASH TECHNIQUE**

B. H. Morrison, D. J. Klein, and L. R. Cowder 1965 34 p refs Presented at the 5th Thermal Conductivity Conf., Denver Submitted for Publication

(Contract W-7405-ENG-36)

(CONF-651020-1; LA-DC-7456) CFSTI: HC \$2.00/MF \$0.50

The pulse technique was applied to the measurement of the thermal diffusivity of tantalum and three grades of graphite over the 800° to 2200° C temperature range. A ruby laser system was used as the pulsed energy source; a photomultiplier tube detected the transient time-temperature response of the back face of a thin sample. Corrections for the heat loss and finite pulse-time are included in the calculations for thermal diffusivity. The data for tantalum are in good agreement with literature values. The laser pulse technique was found to be a convenient, rapid, and precise method for routinely measuring the thermal diffusivity of small samples of solid materials. The extension of the technique to 3000° C and the simultaneous measurements of specific heat are discussed.

Author (NSA)

**N66-19615\*** Hughes Aircraft Co., Fullerton, Calif.  
**LASER WELDING OF COATED MAGNET WIRE** Final Report

J. R. Shackleton and L. J. Martin 17 Nov. 1965 41 p refs Prepared for JPL

(Contract NAS7-100)

(NASA-CR-70935; FR-65-10-257) CFSTI: HC \$2.00/MF \$0.50 CSCL 20E

Techniques are described for performing laser welds of polythermaleze coated magnet wire to stainless steel and gold plated nickel terminals without using conventional methods for stripping the magnet wire. Good high strength welds were made between the desired terminal materials. Low strength welds could be detected visually by the necking down of the wire adjacent to the weld. It was reported that necking down of the wire was caused by variations in heat input into the weld, as excessive heat causes excessive fusion and necking down. More precise laser control is necessary when working with finer wire. By rejecting welds showing a neckdown of the wire, and precisely controlling the laser so that excess fusion

and necking down do not occur, consistently high strength welds can be obtained. Tables and comments on the data accumulated are appended. H.S.W.

**N66-19703#** Naval Ordnance Test Station, China Lake, Calif.

**GaAs INJECTION LASER INVESTIGATION Technical Progress Report No. 377**

Donald G. Mc Cauley Oct. 1965 60 p refs  
(NOTS-TP-3655; AD-624935) CFSTI: HC \$3.00/MF \$0.75

This is one in a series of reports to be published on laser technique and application studies. It documents an investigation in which coherent light emission was obtained from a General-Electric Company GaAs p-n junction injection laser. With current densities in excess of 2,400 amp/sq cm, increased external quantum efficiency, spectral line narrowing, and a high degree of primary source coherence of the radiation were shown. The spectral distribution, which is highly dependent on the current-induced changes in the junction temperature during a single injection pulse, was recorded photographically using a new application of the pulsed-intensity oscilloscope technique. Infrared sheet film was exposed to the radiation below, near, and far above threshold resulting in no, a few, and a great many interference fringes, respectively. There is up to 50% error in the quantitative data presented here, which is not unusual for injection laser investigations; however, the qualitative trends toward spectral line narrowing and high external quantum efficiency support the argument for the optical pumping of neodymium glass and calcium fluoride lasers. Author (TAB)

**N66-19855#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**AMMONIA MASER (AMMONIA MOLECULAR GENERATOR)**

N. A. Begun, V. P. Yegorov, V. V. Il'in, and V. Ye. Petrov 27 Oct. 1965 7 p. Transl. into ENGLISH from Soviet Patent no. 160727 (Appl. no. 790507/26-9. 8 Aug. 1962) 2 p (FTD-TT-65-803/1+2+4; AD-625196) CFSTI: HC \$1.00/MF \$0.50

The object of the invention is an ammonia molecular generator with opposing beams which has the distinguishing feature that, for the purpose of lengthening the period of uninterrupted working, through the means of avoiding the deposition of particles of the active substance of a high vacuum pump on the working surfaces of the high frequency resonator, and simplification of the design of the generator through the exclusion of cryogenic substance, there are used extended multi-channel pickups of the beams of the ammonia with six and eight-field sorting systems and heating of the high-frequency generator. Author (TAB)

**N66-19899#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**RADIATION BEHAVIOR OF MOLECULES IN THE DETUNING CAVITY AND OSCILLATION PHENOMENA OF A DOUBLE-CAVITY MASER**

Tieh-Cheng Lee and Li-Chih Fang 6 Jan. 1966 15 p refs Trans. into ENGLISH from Wu Li Hsueh Pao (Peking), v. 20, no. 8, 1964 p 753-759 (FTD-TT-65-888/1+2+3+4; AD-626953) CFSTI: HC \$1.00/MF \$0.50

A quantum-mechanical treatment is presented of the radiation behavior of molecules in the detuning cavity. The phenomenon that was discovered by Higa (Rev. Sci. Instr., 28 1957, p. 726) in his experiment with a double-cavity maser is explained, namely, when the detuning frequency of the first cavity reaches a certain critical value, the ammonia molecules in the second cavity suddenly break out into oscillation at the

central frequency. A critical formula for the detuning that excites such sudden oscillation is obtained. The influence of the cooperation effect is also taken into consideration. Also qualitatively explained is the experiment performed by Strakhovskiy et al. (J. Exp. Theor. Phys., 42, 1962, p. 907) which relates the degree of detuning in first cavity with the radiative power of the molecules in second cavity. Author (TAB)

**N66-19914#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**STUDYING THE RADIATION SPECTRUM OF A RUBY LASER AND ITS RELATIONSHIP WITH RESONATOR PROPERTIES**

F. A. Korolev and S. M. Mamedzade 13 Jan. 1966 12 p refs Transl. into ENGLISH from Vestn. Mosk. Univ., Ser. III, Fiz.-Astron. (Moscow), no. 2, 1965 p 35-39 (FTD-TT-65-1312/1+2+4; AD-626959) CFSTI: HC \$1.00/MF \$0.50

The complex Fabri-Perot standard (multiplex) in a wedge like and crossed regime was accepted for the investigation of resonant oscillation radiation types of a ruby laser at room temperature. The outer dielectric mirrors and the frontal edges of the ruby crystal constituted the complex resonator, in which various forms of oscillation originated, corresponded to various resonator components. The multiplex standard, working in wedge shaped and crossed condition with various thicknesses of thrust rings, enabled to solve components of ultra-thin structure of the ruby laser spectrum with complex resonator. Author (TAB)

**N66-19918#** Linde Co., East Chicago, Ind.

**PRODUCTION ENGINEERING MEASURE FOR RUBY LASER RODS. Quarterly Progress Report, Jul. 1-Sep. 30, 1965**

B. H. Heise [1965] 16 p  
(Contract DA-36-039-AMC-06168(E))  
(QPR-1; AD-626212) CFSTI: HC \$1.00/MF \$0.50

The document reports progress toward improving the ruby growth process for the manufacture of Rangefinder laser rods. The work of the first quarter involved procurement of equipment, preliminary growth of crystals, improvement of growth apparatus, and initial runs investigating individual variables of the Verneuil growth process. Preliminary growth was performed: viz., shakedown for the two stations assigned to the project, and determination of the present status of crystal growth performed on two additional stations on temporary loan. The crystals produced in the latter investigation await evaluation. A means for accurately controlling the distance between the boule cap and the burner head was devised and installed and is now operating satisfactorily. A means for obtaining a continuous flow of powder was devised. This apparatus will be installed and tested on a growth station during the next quarter. Investigations of the effect of varying the diameter of the boule and the distance between the boule cap and the burner are well under way. Crystals produced in these investigations now await evaluation. All items on the critical path of the PERT diagram are on or ahead of schedule. Fabrication and active evaluation are temporarily behind schedule but these items do not lie on the critical path. Author (TAB)

**N66-19957#** Illinois State Water Survey, Urbana. Atmospheric Sciences Section.

**EVALUATION OF THE MASER-EQUIPPED RADAR SET AN/MP8-34 AND AREA PRECIPITATION MEASUREMENT INDICATOR Quarterly Progress Report, 1 Jul.-30 Sep. 1965**

R. E. Rinehart and D. M. A. Jones 29 Oct. 1965 20 p  
(Contract DA-28-043-AMC-01257(E))  
(QPR-2: AD-625760) CFSTI: HC \$1.00/MF \$0.50

Difficulties encountered with the Area Precipitation Measurement Indicator (APMI) and progress in overcoming these problems are discussed briefly. The MASER-equipped MPS-34 radar was operated during August near Magdalena, New Mexico, and 49-3/4 hours of data were collected of which 18 hours were on MASER mode. Nearly 700 feet of radar film collected on 19 days of operations are available for analysis. The MASER operation was limited by the occasional lack of helium, and for a short period by trouble with the pump klystron circuits. An addition was made to the elevation control system to provide smoother scanning in the RHI mode and to permit the RHI mode to be photographed through the same indicator system as the PPI mode. Analysis of data collected during August in New Mexico was limited to unusual echoes which appeared as coherent targets up to 42 db below full gain without the MASER operating. The conclusion is that these targets were birds.

Author (TAB)

**N66-20024#** Texas Univ., Austin. Plasma Dynamics Research Lab

**INFRARED MASER INTERFEROMETRY FOR TIME AND SPACE RESOLUTION OF ELECTRON DENSITY IN HIGH TEMPERATURE PLASMAS** Technical Report No. 1

Robert F. Gribble, J. P. Craig, and Arwin A. Dougal Wright-Patterson AFB, ARL Jul. 1965 132 p refs  
(Contract AF 33(657)-11073)

(ARL-65-135: AD-626939) CFSTI: HC \$4.00/MF \$1.00

A 3.39  $\mu$  He-Ne maser excited infrared interferometer was utilized for the investigation of time and space resolved electron density in a high temperature, dense plasma formed in the theta-pinch geometry. Dispersion of the coherent infrared radiation by the plasma electrons within an external resonator pulls the frequency of the coupled maser resonator with a resultant change in intensity. The maximum measurable electron density time variation of  $3 \times 10^{16} \text{ cm}^{-3} \mu\text{s}^{-1}$  is achieved with a fast In As infrared detector, the resonators were operated with low coupling and at a relatively low Q. New diagnostic information on the magnetic compression of a Deuterium plasma is presented.

Author (TAB)

**N66-20037#** Pennsylvania State Univ., University Park. Dept. of Physics.

**THRESHOLD FOR STIMULATED RAMAN SPECTRA**

R. V. Wick, T. A. Wiggins, and D. H. Rank [1965] 8 p refs  
Sponsored by Nonr

The effects of power and path length on the threshold for stimulated Raman production in methane and hydrogen were studied. A Korad giant pulse laser with a 3/8 by 4 in. ruby rod was used. The spectra were observed using gas cells of length 6, 20, and 100 cm. in length. The gain per unit length in intensity for a stimulated Raman line is a function of gas density, incident light or power intensity per unit area, line width, and molecular parameters. The independence of gain with focal length was verified using a six cm cell with a five cm lens and a 100 cm cell with a 50 cm lens. In both cases, the second anti-Stokes line vanished for pressures less than 55 lbs/in<sup>2</sup>. Using a 20 cm cell with a 25 cm lens the pressure threshold of the first anti-Stokes line in methane was observed to be 70 lbs/in<sup>2</sup>; with a 50 cm lens and the same power, the threshold was 180 lbs/in<sup>2</sup>. In hydrogen, using a 100 cm cell with a 50 cm lens, the anti-Stokes line was not present below 260 lbs/in<sup>2</sup> for a constant line width; using a 20 cm cell the green anti-Stokes line vanished at 215 lbs/in<sup>2</sup>.

D.T.

**N66-20166#** ITT Industrial Labs., Fort Wayne, Ind.  
**IMPROVED QUANTUM EFFICIENCY LASER DETECTORS**  
Interim Engineering Report

K. R. Crowe and J. L. Gumnick 20 Jan. 1966 33 p ref  
(Contract AF 33(615)-3082)

(ITTIL-66-1002: AD-627046) CFSTI: HC \$2.00/MF \$0.50

This report covers the theoretical and experimental work completed during the first 4 months of the contract. An equation was derived relating photoelectric response to the optical and solid-state properties of photoemitters. The analysis includes the influence of multiple reflections of light from the photocathode boundaries and shows interference enhanced photoresponse for certain values of wavelength of the incident radiation and photocathode thickness. Photoelectric response for light entering the photocathode from the vacuum interface is compared to the response for light entering the photocathode from the glass interface for S-1 and S-20 photocathodes. The yield is generally found to be higher for light entering the photocathode from the glass substrate. It is believed that the relative yields of the two cases is partially determined by multiple reflections within the photocathode. The measurements of photoelectric yield versus photocathode thickness and experimental problems relating to the measurements are discussed. Experiments to be conducted during the remaining month of the contract are outlined.

Author (TAB)

**N66-20322#** Sandia Corp., Livermore, Calif.

**FRINGE COUNTING LASER INTERFEROMETERS FOR INDUSTRIAL LENGTH MEASUREMENT**

J. D. Foster (Ph.D. Thesis—Calif. Univ., Berkeley) Sep. 1965 204 p refs

(Contract AT(29-1)-789)

(SCL-DC-65-92) CFSTI: HC \$6.00/MF \$1.25

The use of fringe-counting Michelson interferometers for length measurement has been restricted due to the problems of short measuring range and sensitivity to disturbance. The helium-neon gas laser is shown to be the answer to these problems. Use of the gas laser is shown to remove the measuring range limitations and to permit the design of solid integral interferometer systems with ruggedness and reliability, which allows their use in normal industrial environments. A theoretical model for the Michelson interferometer illuminated with a helium-neon gas laser (laser interferometer) is presented. Calculations of the variations in interference fringe visibility as a function of measuring distance made with this model are shown to agree with experiment. Design considerations for stabilized single-frequency laser cavities are given. A solid integral interferometer system with fringe counting electronics is described. Experimental results are given, which demonstrate the accuracy and long-range measuring capabilities of the system.

Author (NSA)

**N66-20355#** California Univ., Livermore. Lawrence Radiation Lab.

**THEORY OF COUPLED-MODE LASER OSCILLATIONS**

J. A. Fleck, Jr. and R. E. Kidder 8 Apr. 1964 33 p refs  
(Contract W-7405-ENG-48)

(UCRL-7497) CFSTI: HC \$2.00/MF \$0.50

A set of general equations describing the time-dependent behavior of a laser is derived. The derivation is based on a density matrix description of the occupation of a pair of homogeneously broadened laser levels and a semi-classical treatment of the radiation field, consisting of an arbitrary number of modes. The resulting equations resemble ordinary rate and energy conservation equations but contain additional interference terms which, in general, couple all of the

modes. The strength of this coupling depends on the inhomogeneity of the population inversion as well as on the mode frequencies. The energy conservation equations imply that absorption and stimulated emission in such a system can apply, strictly speaking, only collectively to the system of modes as a whole. Stability analysis carried out in the two-mode case indicates that a spatial inhomogeneity in the pumping rate is required for undamped oscillations. It is also concluded that coupling of off-axis modes is more likely to lead to undamped spiking than coupling of axial modes.  
Author (NSA)

**N66-20388#** Iowa State Univ. of Science and Technology, Ames. Inst. for Atomic Research.

**STIMULATED COMPTON SCATTERING OF ELECTRONS BY LASER BEAM**

L. S. Bartell and H. Bradford Thompson 4 Jul. 1965 8 p refs  
Presented at the Phys. of Quantum Electron. Conf., San Juan, Puerto Rico, 28-30 Jun. 1965  
(Contract W-7405-ENG-42)

(S-1187; CONF-650638-1) CFSTI: HC \$1.00/MF \$0.50

The scattering of a beam of electrons by intense standing waves of photons inside a laser cavity was recently observed. It is believed that this scattering corresponds to the stimulated Compton effect predicted by Kapitza and Dirac many years ago. The analogy between this effect and its inverse, the scattering of photons by a periodic lattice of electrons, is discussed along with several experimental observations and possible applications.  
Author (NSA)

**N66-20553#** Brookhaven National Lab., Upton, N. Y.

**LASER FLASH TUBE TRIGGERING SYSTEM**

D. Stephani 3 Jun. 1965 6 p

(Contract AT(30-2)-GEN-16)

(BNL-9257) CFSTI: HC \$1.00/MF \$0.50

A circuit is designed to fire Xe flash tubes used in a laser system. An Al reflector, which completely encircles the laser crystal and the flash tubes, is grounded. A small wire loop is wrapped around the flash tube at the ground, just above the grounded electrode. This wire is coupled to the high voltage pulsed electrode through 50 pf. This expedient produces reliable firing of the flash tubes for high voltage supplies of 800 to 2800 V. In the configuration used, four flash tubes are spaced uniformly around the laser crystal, and the described circuit is used to fire all four of the tubes.  
NSA

**N66-20600#** United Aircraft Corp., East Hartford, Conn. Research Labs.

**INVESTIGATION OF THE MECHANISMS ASSOCIATED WITH GAS BREAKDOWN UNDER INTENSE OPTICAL ILLUMINATION** Semiannual Report, Aug. 1-Dec. 31, 1965

Alan F. Haught and David C. Smith Jan. 1966 24 p refs  
(Contract Nonr-4696(00); ARPA Order 306; Proj. Defender)  
(UACRL-E920272-6; AD-627233) CFSTI: HC \$1.00/MF \$0.50

An experimental and theoretical study of the physical processes leading to the ionization of gases by intense optical radiation was conducted. The high-intensity beam from a Q-spoiled ruby or neodymium laser is focused by a lens and used to cause electrical breakdown in a test gas. The production of ionization is examined as a function of the laser beam intensity, gas type, pressure, volume within which the breakdown occurs, and frequency of the radiation. Studies have been made of the breakdown threshold of mixtures of the inert gases to determine the effects of controlled impurity levels on the breakdown process. In these experiments it was found that at  $5 \times 10^4$  mm Hg the breakdown threshold of a 1 per cent neon, 99 per cent argon gas mixture was lower than that for pure

argon, even though at any given pressure the breakdown threshold of neon alone is greater than that for argon. Measurements of the pressure dependence of the breakdown threshold of the gas mixture show the importance of gas collisions in the development of breakdown at high pressures and suggest that radiation energy transport may be the diffusion-like loss reported earlier. To examine further the growth of the breakdown region, studies have been made of the expansion of the breakdown plasma using a high-speed image.  
Author

**N66-20730** General Telephone and Electronics Labs., Inc., Bayside, N. Y.

**COORDINATION AND CHEMICAL EQUILIBRIUM IN CHELATE LASER MATERIALS**

H. Samelson, C. Brecher, and A. Lempicki In Iowa State Univ. of Sci. and Technol. 5th Rare Earth Res. Conf. Book 1: Spectra Symp. Session S-1 and Spectra Session S-2 [1965] p 41-52 refs (See N66-20726 10-26) CFSTI: HC \$5.00/MF \$1.00

Chelated rare earth ions have been found to exist in solution in a multiplicity of molecular structures, differing in the number and geometrical arrangement of coordinating ligands. Eight-fold coordination is the most common, but changes in temperature, solvent, or substituent groups may alter the coordination in either direction. Furthermore, most chelates dissociate progressively further as their concentration is lowered. The ramifications of such behavior on their luminescence and laser applications will be discussed.  
Author

**N66-20809#** Radio Corp. of America, Princeton, N. J. RCA Labs.

**ROOM TEMPERATURE LASER DIODES** First Quarterly Report, Jul. 1-Sep. 30, 1965

George C. Dousmanis, Aline Akselrad, and Herbert Nelson Ft. Monmouth, N. J., Army Electron. Command, Oct. 1965 21 p refs

(Contract DA-28-043-AMC-01501(E))

(ECOM-01501-1; AD-626775) CFSTI: HC \$1.00/MF \$0.50

The performance of pulsed GaAs injection lasers has been studied at repetition rates as high as 30 kc/sec with 80-nsec-wide pulses. Peak power outputs of 10 watts are obtained with 40 A at low repetition rates (0.1 to 10 kc/sec). At 30 kc/sec the power output is 4.5 watts. These results apply to the conventional parallelepiped structure (junction width approx. 0.0075 cm and length 0.025 cm). The experimental results up to 30 kc/sec suggest power outputs of about 1 W at 100 kc/sec, despite some temperature rise with repetition rate indicated by approximate calculations on heating effects. A new 'line diode' structure is described which embodies a large area p-n junction but with a lasing region width of less than 0.0025 cm. An improved performance is expected at high repetition rates from these units.  
Author (TAB)

**N66-20850#** Illinois Univ., Urbana. Dept. of Theoretical and Applied Mechanics.

**DYNAMIC STRESS CONCENTRATION USING PHOTO-ELASTICITY AND A LASER LIGHT SOURCE**

W. P. T. North and C. E. Taylor Sep. 1965 23 p refs

(Grant NSF GK-70)

(T&AM-285)

Since experimental techniques using dynamic photoelasticity are in general limited by suitably intense monochromatic light sources, it was of primary importance to describe a ruby laser system which would completely remove this particular aspect of the problem. Modulation of the system, in this case by a Kerr cell, provides the necessary control of the light output such that a complete series of results can be obtained by

- putting together the results of many individual tests recorded on a conventional still camera. In this case the dynamic stress concentration factor in a strut with a symmetrically located circular discontinuity was determined to definitely establish the potential of the system. Author

**N66-20857#** Frankford Arsenal, Philadelphia, Pa. Research and Development Directorate.

**BASIC THEORETICAL CONSIDERATIONS OF LIGHT AMPLIFICATION BY STIMULATED EMISSION OF RADIATION**

Alexander J. Casella Nov. 1964 56 p refs

(R-1743; AD-612516) CFSTI: HC \$3.00/MF \$0.75

A theoretical development of the basic physical principles of Light Amplification by Stimulated Emission of Radiation (LASER) is presented. The processes of absorption and emission are presented in a general manner, using both a classical and quantum mechanical approach. The classical approach involves the approximation of the motion of an atomic electron as a driven oscillator. The quantum mechanical approach employs the time-dependent perturbation approximation to develop the transition rates for absorption and emission. A brief discussion of the lifetime and spectral line width of excited energy states is presented due to their importance in considerations of the LASER. Following this general development of the absorption and emission processes, a qualitative discussion of the important aspects of the LASER mechanism is presented. A quantitative development of the conditions for amplification for the two basic types of LASER (the three-level and four-level types) is presented using ruby and neodymium-doped glass as typical examples. Author (TAB)

**N66-20941\*#** Radio Corp. of America, Camden, N. J.  
**LASER COMMUNICATION TRANSMITTER Final Report**  
Nov. 1965 54 p

(Contract NAS9-4473)

(NASA-CR-65246) CFSTI: HC \$3.00/MF \$0.50 CSCL 20E

The objective of this program was to design and fabricate three injection laser transmitters to be used as part of the GT-7 Gemini experiments. One transmitter will be used by an astronaut to establish an experimental laser communication link with a ground receiving station at White Sands missile range. The remaining units will be used for qualification tests and as back-up units. Author

**N66-21037\*#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**EFFECT OF IONIZING RADIATION ON RUBY**

Americo F. Forestieri and Hubert H. Grimes Washington, NASA, Apr. 1966 11 p refs

(NASA-TN-D-3379) CFSTI: HC \$0.15/MF \$0.50 CSCL 20L

The ability of ruby to operate as a laser is dependent on the presence of chromium<sup>+3</sup> (Cr<sup>+3</sup>) impurity ions. Since radiation can cause severe ionization effects in ionic solids, it is desirable to determine whether ruby would be affected by such a radiation field. High-purity ruby and  $\alpha$ -aluminum oxide ( $\alpha$ -Al<sub>2</sub>O<sub>3</sub>) were studied by optical absorption and electron paramagnetic resonance techniques both before and after irradiation with high-energy X-rays. Irradiation of ruby crystals which have been preannealed in air results in a 20-percent loss of Cr<sup>+3</sup>, the formation of Cr<sup>+4</sup> and Cr<sup>+6</sup> ions, and an unidentified V-type defect center. The effects found indicate complex interactions which depend strongly on the crystal pretreatment, purity, and irradiation dose. Probable ionization processes are given to account for the results observed. Author

**N66-21141#** Institut für Plasmaphysik G.m.b.H., Garching (West Germany).

**DEVELOPMENT OF A LASER AMPLIFIER AND ITS APPLICATION IN PLASMA DIAGNOSTICS [ENTWICKLUNG EINES LASER-VERSTÄRKERS UND SEINE ANWENDUNG IN DER PLASMA-DIAGNOSTIK]**

H. Zietemann Jun. 1965 35 p refs In GERMAN; ENGLISH summary

(IPP-1/42) CFSTI: HC \$2.00/MF \$0.50

In order to measure the electron temperature and the electron density of a 26 K Joule  $\Theta$ -pinch by means of light scattering, a high power laser has been assembled by combining an oscillator laser and an amplifier laser. The amplification of the oscillator impulse by the ruby of the amplifier laser was calculated and measured. The amplification is expressed as function of the temperature of the amplifier ruby. Maximum impulse power: 25 MW. During the first maximum compression the maximum electron temperature was 50 eV, and at the moment of the maximum B-field the maximum temperature was 85 eV. The corresponding electron densities were measured as max.  $1.3 \times 10^{17}$  particles/cm<sup>3</sup> and  $1.6 \times 10^{17}$  particles/cm<sup>3</sup> respectively. The spatial distribution of electron temperature and electron density in the plasma is also stated. Author

**N66-21169#** Materials Research Corp., Orangeburg, N. Y.  
**INVESTIGATION OF ELECTRON BEAM PROCESSING OF ALUMINUM OXIDE AND RELATED MATERIALS Scientific Report No. 3**

W. Class, Harvey R. Nesor, and G. T. Murray 15 Dec. 1965 refs

(Contract AF 19(628)-4089)

(AFCRL-65-908; AD-626754) CFSTI: HC \$3.00/MF \$0.50

This investigation deals with the application of float-zone techniques to the growth of laser ruby crystals. Two techniques, the electron beam and the hollow cathode float-zone processes, are being studied. The electron beam float-zone technique has yielded high perfection sapphire crystals free of visual scattering centers. Crystals grown by this technique show a preferred orientation of about 85 degrees as compared with flame-fusion crystals which show a 60 degrees preferred orientation. Doping of the sapphire with Cr<sub>2</sub>O<sub>3</sub> has been accomplished with the aid of oxide melting point depressants. The resulting ruby, however, still exhibits optical scattering. These centers can be attributed to starting material inhomogeneity. Efforts are presently underway to improve the starting material quality. The hollow cathode float-zone technique makes use of a highly localized hollow cathode plasma to produce a molten zone. This technique is currently being developed in an effort to carry out float-zone crystal growth at pressures higher than are permissible with the electron beam technique. The technique has been developed to the stage where floating zones have been produced and scanned. Large crystals have not yet been produced; further improvements in plasma stability must be accomplished before large crystals can be grown by this technique. Author (TAB)

**N66-21293#** Army Electronics Labs., Fort Monmouth, N. J.  
**HIGH-POWER GALLIUM ARSENIIDE LASER DIODES**  
L. Wandinger and K. L. Kohn Oct. 1965 24 p refs

(ECOM-2629; AD-627084) CFSTI: HC \$1.00/MF \$0.50

The essential features in the design, development, and performance of GaAs p-n junction laser diodes with high output in the coherent beam for application in secure communication systems are discussed. After a brief review of device design principles, the technology of wafer preparation, diffusion of extremely planar p-n junctions and the formation of ohmic, low resistance, area contacts developed at this

Command is presented. Measurement techniques to determine the performance characteristics of these lasers such as threshold current density, output power, external quantum efficiency, spectral distribution and linewidth of emitted radiation are discussed. Experimental units with a total average power output in the coherent beam of more than three watts corresponding to a quantum efficiency of 15 percent have been made.

Author (TAB)

**N66-21405#** Sylvania Electric Products, Inc., Mountain View, Calif. Electronic Defense Labs.

**TECHNIQUES FOR SUPER-MODE OSCILLATION** Interim Engineering Report, 1 Sep.-30 Nov. 1965

Russell Targ, B. J. Mc Murtry, and S. E. Harris [1965] 53 p refs

(Contract AF 33(615)-2884)

(IER-2; AD-624845) CFSTI: HC \$3.00/MF \$0.50

The report describes an experimental and theoretical program to determine the fundamental properties of the FM and super-mode lasers. These two techniques make it possible to obtain at a single frequency the full power of a high-power multi-mode laser without suffering the loss in power inherent in conventional approaches involving the suppression of modes. The work of this program is divided broadly between two main activities. The first is to obtain a more complete understanding of the physics governing the operation of the FM and super-mode lasers. The second is concerned with improving the techniques for coupling the modes of the FM laser and finding more efficient means for full power super-mode conversion of the FM signal to a monochromatic output. Progress to date is summarized.

TAB

**N66-21435\*#** Radio Corp. of America, Princeton, N. J. Microwave and Power Devices Operations Dept.

**DESIGN AND FABRICATION OF A LASER MODULATOR** Final Report, Jul. 27-Oct. 27, 1965

11 Nov. 1965 28 p refs

(Contract NAS5-9620)

(NASA-CR-71516) CFSTI: HC \$2.00/MF \$0.50 CSCL 16E

The development of a laser modulator capable of producing 40% depth of modulation for an applied voltage of 400 volts rms over a bandwidth from dc to 6 Mc/sec is presented. The program incorporated a parallel effort on both gallium arsenide and gallium phosphide electro-optic crystals. In addition, some work was done on potassium tantalate niobate. An attached paper gives a summary description of GaAs electro-optic modulators having a linear aperture of 3 mm x 3 mm and an angular aperture greater than 12 degrees.

C.T.C.

**N66-21657\*#** Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics.

**SENSING OF METEOROLOGICAL VARIABLES BY LASER PROBE TECHNIQUES** Semiannual Report, 1 Aug. 1965-31 Jan. 1966

G. Fiocco 1 Feb. 1966 7 p refs

(Grant NGR-22-009-131)

(NASA-CR-71397) CFSTI: HC \$1.00/MF \$0.50 CSCL 04B

Optical radar investigations of the aerosol layer at 20 km have continued and noctilucent cloud observations were analyzed in connection with a study dealing with the sensing of meteorological variables by laser probe techniques. Work is underway on the development of a Doppler optical radar, and an experiment is proposed to measure Raman scattering of ruby light in the atmosphere.

M.W.R.

**N66-21698\*#** National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.

**HYDROGEN MASER FREQUENCY COMPARISON WITH A CESIUM BEAM STANDARD**

E. H. Johnson and T. E. Mc Gunigal Washington, NASA, Apr. 1966 15 p refs

(NASA-TN-D-3292) CFSTI: HC \$0.20/MF \$0.50 CSCL 20E

A direct measurement of the hyperfine energy-level splitting (splitting the energy band into sublevels) of the hydrogen atom has been made by comparing the frequency of an atomic hydrogen maser and a cesium-beam frequency standard. The two standards were compared for the period of one day. The measured value of the  $F=1$ ,  $M_f=0 \rightarrow F=0$ ,  $M_f=0$  hyperfine transition corrected to zero field is  $1420405751.781 \pm 0.016$  (A-1 Time Scale).

Author

**N66-21774#** Hughes Aircraft Co., Fullerton, Calif.

**LASER COMMUNICATIONS STUDY** Final Report, 1 Jul. 1964-31 Aug. 1965

T. M. Straus, J. E. Kiefer, and F. Chethik Jan. 1966 88 p refs

(Contract DA-28-043-AMC-00195(E))

(FR-66-14-37; AD-477691)

The design of a laser communications system was predicated upon obtaining a tool with which the deleterious effects of the atmosphere on a FM signal could be measured. The system incorporates the elements of a coherent communications system with sufficient bandwidth to handle a 12 voice channel binary multiplex. Modulation of the light is accomplished in the UHF region. This is a single-ended system (i.e. a mirror is used at one end) utilizing a single laser to provide LD and signal beam power. The system design was implemented during the development phase. A two-element electro-optic modulator enclosed in a UHF cavity to obtain the desired frequency translation is described. In an additional operational mode the carrier is not suppressed and the local oscillator is transmitted with the signal. Atmospheric path study tests showed both modes were at times greatly degraded by atmospheric turbulence. This is primarily attributed to thermal gradients in the atmosphere. The heterodyne signal degraded more than the self-mix (carrier plus sideband) mode.

Author (TAB)

**N66-21833#** Northeastern Univ., Boston, Mass. Photochemistry and Spectroscopy Lab.

**APPARATUS FOR FLASH PHOTOLYSIS** Scientific Report No. 3

Peter A. Schnieper Jul. 1965 51 p refs

(Contract AF 19(628)-3836; Grant PHS-RH-00302-02)

(PSL-102; AFCRL-65-716; AD-627533) CFSTI: HC \$3.00/MF \$0.50

Flash photolysis provides a means of studying the short-lived chemical intermediates which result from exposure to light. The paper describes the instrumentation for this technique developed at Northeastern University. Details are presented of the main discharge circuit, of the flash tubes, and of the trigger, delay, and detection circuits. A flash photolysis assembly based on the pulsed ruby laser is also described. The photolysis of aqueous methylene blue serves to illustrate the performance of the apparatus.

Author (TAB)

**N66-21862#** Library of Congress, Washington, D. C. Aerospace Technology Div.

**FOREIGN SCIENCE BULLETIN, VOLUME 2, NUMBER 3** Mar. 1966 80 p refs

Presented is a compilation of selected foreign scientific and technical literature sponsored by the Department of Defense. Some of the topics considered are: the method of

- potential functions, two-photon optically pumped semiconductor lasers, the controlling zone in the combustion of composite propellants, new trends in the development of aromatic polyesters in the USSR, loss in antenna gain in long-haul UHF tropospheric propagation, microwave techniques for lasers, solid fuels for ramjet engines, high-temperature properties of liquid alkali metals, and effect of fillers on the morphological forms and mechanical properties of crystalline polymers. Reports are included on the following conferences: the spectral transparency of the atmosphere in the visible and infrared regions of the spectrum, and problems in material science. Reviews are presented for the following books: *Molecular Scattering of Light*, and *Methods of Studying the Most Recent and Contemporary Tectonics of the Shelf Zones of Seas and Oceans*. A brief biography on Lev Davidovich Landau is also included. M.R.W.

**N66-21887#** California Inst. of Tech., Pasadena. Hydrodynamics Lab.

**PARAMETERS AFFECTING CAVITATION AND SOME NEW METHODS FOR THEIR STUDY Final Report**

Albert T. Ellis Oct. 1965 48 p refs

(Contract Nonr-220(44))

(E-115.1; AD-627925) CFSTI: HC \$2.00/MF \$0.50

New experimental observations are presented which support the high speed jet mechanism of cavitation damage. A general discussion of the basic hydrodynamic theory involved is given and the importance of certain parameters on damage are pointed out. New techniques for studying the collapse of single cavities are described and the concept and development of a high speed photographic system using a ruby laser is outlined. Magnifications of up to fifty times at picture repetition rates as high as 1,600,000 per second and exposure times of 20 billionths of a second have been achieved. Author (TAB)

**N66-22191\*#** National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.

**TRACKING OF THE BEACON-EXPLORER SATELLITES WITH LASER BEAMS**

Henry H. Plotkin [1965] 4 p refs Submitted for Publication (NASA-TM-X-56631) CFSTI: HC \$1.00/MF \$0.50 CSCL 20E

The value of using lasers for accurate tracking of orbiting optical reflectors is assessed. Results of optical tracking experiments with the Beacon Explorer satellites indicate that precise measurements of satellite positions may be determined. Present optical tracking methods require photography by reflected sunlight at a time when the sky is dark enough to permit simultaneous photography of the stars, however it is observed that studies are being conducted to permit laser range determinations during daylight and when the satellite is in the shadow of the earth. H.S.W.

**N66-22300\*#** National Aeronautics and Space Administration, Washington, D. C.

**VISUAL OBSERVATION OF INFRARED LASER EMISSION [O VIZUAL'NOM NABLYUDENII INFRAKRASNOGO IZLUCHENIYA OPTICHESKOGO KVANTOVOGO GENERATORA]**  
L. S. Vasilenko, V. P. Chebotayev, and Yu. V. Troitskiy Feb. 1966 8 p ref Transl. into ENGLISH from Zh. Eksperim. Teor. Fiz. (Moscow), v. 48, Mar. 1965 p 777-778

(NASA-TT-F-9888) CFSTI: HC \$1.00/MF \$0.50 CSCL 06D

Description of experiments in visual perception of intense coherent infrared radiation. Radiation of 0.95, 1.11, 1.15 and 1.18  $\mu$  from a gas laser was observed with the unaided eye. Radiation with  $\lambda=0.95 \mu$  is perceived as red light, while radiation with  $\lambda=1.11, 1.15$  and  $1.18 \mu$  is perceived as light with half the wavelength of red light. Author

**N66-22338\*** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville Ala.

**DEVELOPMENT OF A LASER DOPPLER FLOWMETER FOR GAS VELOCITY MEASUREMENT**

W. Foreman (Brown Eng. Co.) and Robert M. Huffaker *In its* Aero-Astrody. Res. Rev. No. 3 15 Oct. 1965 p 66-71 refs (See N66-22329 11-34) CFSTI: HC \$4.00/MF \$1.00

The large magnitudes of the Doppler shifts obtainable, using a cw gas laser, suggest that local velocity vectors can be measured by using the visible light from the laser. Optical heterodyning of the laser light with a portion of the incident laser beam will produce a beat signal at the frequency of the Doppler shift due to the motion of the gas. Measurement of the beat signal frequency, together with the geometry of the optical system, determines the flow velocity of the gas. A probeless velocity measuring technique has been developed based on this principle. This technique has been checked in a wind tunnel at speeds up to 500 ft/sec (150 m/sec). This technique also gives a distribution of velocities due to the turbulence level of the gas flow. This technique is also applicable for the measurement of velocity of any moving surface. Some applications will be the measurement of panel flutter and for a calibration of dynamic pressure transducers. Author

**N66-22418#** National Bureau of Standards, Washington, D. C.  
**PROCEDURES FOR PRECISE DETERMINATION OF THERMAL RADIATION PROPERTIES, NOVEMBER 1963 TO OCTOBER 1964**

Joseph C. Richmond, S. Thomas Dunn, David P. De Witt, and Warren D. Hayes, Jr. 17 Dec. 1965 77 p refs Prepared for AF

(NBS-TN-267; AD-628586) GPO: HC \$0.45; CFSTI: MF \$0.75

A laser-source integrating sphere reflectometer was designed and built to measure the reflectance of specimens at high temperatures. The sphere was calibrated for linearity of response of 0.632 microns by means of a shallow cylindrical cavity with a variable depth-to-radius ratio, having a lining of known reflectance. Preliminary tests showed that the flux emitted by a hot specimen at temperatures up to 2500°K will not invalidate the reflectance measurement. An ellipsoidal mirror reflectometer was calibrated for all known errors in the 1 to 7.5 microns range. A preliminary analysis indicates that the errors in measurement of absolute reflectance with this equipment should not exceed 2 percent. A review of the literature on relation of thermal radiation properties to other properties of materials is presented, together with a summary of the work done in an effort to compute the spectral emittance of rhodium. Author (TAB)

**N66-22419#** Westinghouse Electric Corp., Baltimore, Md.  
**THERMAL OPTIC DISTORTION Semiannual Report, 16 Jun.-16 Dec. 1965**

J. H. Cullom, E. P. Riedel, and G. D. Baldwin 16 Jan. 1966 40 p refs

(Contract Nonr-4874(00); ARPA Order 306; Proj. Defender) (MDE-6236; AD-628489) CFSTI: HC \$3.60/MF \$0.50

Preliminary measurements were made on a 3/8x3 inch neodymium-doped Kodak glass laser rod. The measurements performed were space and time resolved measurements of pump induced bi-refringence during and after the pump phase. The theoretical portion of the investigation completed covers a preliminary analysis of the pump induced bi-refringence. Two clad neodymium doped laser rods, and one undoped glass control rod, were ordered from the American Optical Company. Author (TAB)



**N66-22449#** Microwave Electronics Corp., Palo Alto, Calif.  
**STUDY OF PHONON-OPTICAL INTERACTIONS Final Report**

F. A. Olson and V. R. Johnson Nov. 1965 46 p refs  
 (Contract AF 49(638)-1330)  
 (AFOSR-65-2647; AD-628020) CFSTI: HC \$2.00/MF \$0.50

Exploratory research is described concerning phonon-photon interactions in optical sources. These include a theoretical description of Bragg and Raman-Nath scattering caused by propagation of a plane acoustic wave through the path of a laser beam. This interaction is considered for intracavity operation with possibilities of modulation, frequency translation and output coupling. The conditions for synchronous mode operation are described. Modulation of an injection laser is considered on a theoretical basis with suggestions as to what results are to be attained and how the concept may be tested. Because boundary conditions are indeterminate for the injection laser, it was felt that experimental research should first deal with the intracavity modulation and coupling in an optically pumped laser. The interaction was tested in a ruby laser. The prime problem was associated with strains set up by the thermal shock created when the laser was operated in a pulsed mode. 850 Mc acoustic wave interaction was observed in the laser, its magnitude slightly above the noise level. Author (TAB)

**N66-22488#** Systems Research Labs., Inc., Dayton, Ohio.  
**EXPERIMENTAL DETERMINATION OF ION EXCITATION ENERGIES AND DENSITIES IN A LOW PRESSURE DISCHARGE Final Report, May 1964-Jun. 1965**

Richard R. Corwin Wright-Patterson AFB, Ohio, ARL, Dec. 1965 42 p refs  
 (Contract AF 33(615)-1798)  
 (ARL-65-246; AD-628795) CFSTI: HC \$2.00/MF \$0.50

An experiment is described for measuring the relative population densities of the energy levels of a neon plasma using a tunable helium-neon laser. Absorption measurements of the laser irradiation upon a neon plasma are made. A phase sensitive lock-in amplifier is used as a detector which measures only the absorption of incident laser radiation and thus eliminates erroneous measurement of background light. Two specially constructed plasma diagnostic instruments are described. The first instrument measures the second derivative of Langmuir probe current with respect to probe voltage, and thus is a measure of the electron velocity distribution in a plasma. This instrument employs a phase sensitive detector which is a theoretically optimum technique for detecting small signals in the presence of noise. The second instrument is a simple logarithmic amplifier which displays, on an oscilloscope, the logarithm of the Langmuir probe current. The slope of the resulting oscilloscope trace is a measure of the electron temperature of the plasma. Author (TAB)

**N66-22498#** Texas Instruments, Inc., Dallas. Apparatus Research and Development Lab.

**LARGE-ANGLE DEFLECTION TECHNIQUES FOR LASER DISPLAY Second Quarterly Report, 19 Aug.-19 Nov. 1965**

G. R. Fournier and H. W. Parker Griffiss AFB, N. Y., RADC, Jan. 1966 32 p ref  
 (Contract AF 30(602)-3731)  
 (U2-912008-2; RADC-TR-65-465; AD-628046) CFSTI: HC \$2.00/MF \$0.50

Work has continued on a large-angle deflection technique for producing a 945 line TV type raster scan in an experimental laser display. A 14° scan-angle was achieved at 28,350 cycles by the horizontal deflector comprised of a piezoelectric cartridge and mirror coupled by a glass resonator shaft.

Cartridges made of PZT-4 material as well as silica fibers are being investigated in an attempt to improve the scanners. Tests to determine angular and lateral deflection, effects of cooling, and mechanical resonant frequencies were performed, and an electrical equivalent circuit was arrived at. Electronic drive circuitry for both horizontal and vertical scanners was further developed. It was concluded that at least 25 factors and variables contribute to the characteristics of the scanners. Other type scanners were also investigated. Author (TAB)

**N66-22582#** Michigan Univ., Ann Arbor. Optical and Radio Systems Lab.

**INVESTIGATION OF SPACE COMMUNICATIONS SYSTEMS USING LASERS Interim Report, Dec. 1963-May 1964**

R. A. Rollin, Jr. and F. Zwas Griffiss AFB, N. Y., RADC, Jan. 1966 180 p refs /ts Rept.-5693-9-T  
 (Contract AF 30(602)-3036)  
 (RADC-TDR-64-289; AD-478052)

Space-to-space and earth-to-space communications systems with laser sources (wavelengths between 0.2313 and 85.047) were studied and analyzed. The general optical-communications range equation was derived using signal to noise considerations for the two systems. The performance of seven laser systems employing state-of-the-art components were compared, with two of the seven including optical maser power amplifiers. A 1.0628 SF<sub>6</sub>+He has laser source with a neodymium optical maser power amplifier performed best for deep space communications from an earth station or from a space vehicle. Studies were made of geophysical and celestial phenomena affecting laser communications, and included investigations of atmospheric transmittance and background interference from celestial bodies. Satellite and ground station spacings for continuous laser space communications were determined, and it was found that three equally spaced synchronous orbiting satellite relays had the best operational characteristics. Conclusions are drawn concerning the best continuous laser wavelength for both types of systems under various conditions, and areas of research are recommended. C.T.C.

**N66-22611#** Illinois Univ., Urbana. Dept. of Electrical Engineering.

**JUNCTION EFFECTS IN COMPOUND SEMICONDUCTORS Scientific Report No. 4**

N. Holonyak, Jr., M. D. Sirkis, C. J. Nuese, J. S. Moore, and G. Stillman Sep. 1965 14 p refs  
 (Contract AF 19(628)-4337)  
 (AFCRL-66-18; AD-629689) CFSTI: HC \$1.60/MF \$0.50

Some results of Zn-diffusion in Ga(As<sub>1-x</sub>P<sub>x</sub>) and their effects of laser junctions are summarized. Pulsed operation of Ga(As<sub>1-x</sub>P<sub>x</sub>) lasers to temperatures beyond 200°K is described. Self-oscillation phenomena (instabilities) in bulk n-type Si counter-doped with Au or Co are discussed briefly. These oscillations occur at typically 1 Mc or lower frequencies in Co-compensated Si and to well above 100 Mc in Au-compensated Si. Author (TAB)

**N66-22741#** Stanford Univ., Calif. Microwave Lab.  
**MICROWAVE RESEARCH Quarterly Status Report No. 27, 1 Aug.-31 Oct. 1965**

Feb. 1966 17 p refs  
 (Contract Nonr-225(48))  
 (ML-1410; AD-628941) CFSTI: HC \$1.60/MF \$0.50

Microwave research is reported in the following areas: (1) acoustic wave amplification in piezoelectric semiconductors; (2) optical masers for physical research problems; (3) stimulated Raman scattering with applications to tunable lasers; (4) the geometry of microwave acoustics; (5) high electric field domain motion in photoconductive and semiconductive cadmium sulfide; (6) longitudinal electronic resonances of bounded, collisionless, and nonuniform plasmas; and (7) bulk instabilities and streaming in ferromagnetic metals. D.T.

**N66-23078#** Utah Univ., Salt Lake City.  
**LASER TEMPERATURE-JUMP STUDIES OF FAST REACTIONS** Final Technical Report, Oct. 1, 1963-Sep. 30, 1965  
 Edward M. Eyring [1965] 7 p refs  
 (Grant AF-AFOSR-476-64)  
 (UUCd-2-64; AFOSR-65-2941; AD-628027) CFSTI: HC \$1.00/MF \$0.50

A ruby laser was assembled from commercial components for use as a single-pulse, source of heat in temperature-jump relaxation kinetic studies of very rapid reactions in aqueous and non-aqueous solutions. Preliminary results were obtained with an aqueous uranyl ion monomer-dimer equilibrium to which copper nitrate was added. A neodymium doped glass laser rod radiating at 1.06 microns was not found satisfactory for the same purpose. A concurrent investigation of a fast protolytic reaction in water and D<sub>2</sub>O by the conventional Joule heating temperature-jump method yielded solvent D<sub>2</sub>O kinetic isotope effect data with ramifications for enzyme kinetics. Author (TAB)

**N66-23456\*** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.  
**ELECTRONICS RESEARCH AT MSFC**  
 1965 40 p *Its Res. Achievements Rev. Ser. No. 5*  
 (NASA-TM-X-53364) CFSTI: HC \$2.00/MF \$0.50 CSCL 09C  
 CONTENTS:

1. OPTICAL TECHNOLOGY PROGRAM J. L. Randall p 1-10 (See N66-23457 12-16)

2. LASER SYSTEMS RESEARCH AT MARSHALL SPACE FLIGHT CENTER C. L. Wyman p 11-19 (See N66-23458 12-16)

3. MICROELECTRONICS PROGRAM AT MARSHALL SPACE FLIGHT CENTER J. C. Taylor p 21-29 (See N66-23459 12-09)

**N66-23457\*** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

**OPTICAL TECHNOLOGY PROGRAM**  
 Joseph L. Randall *In its Electron. Res. at MSFC* 1965 p 1-10 (See N66-23456 12-09) CFSTI: HC \$2.00/MF \$0.50

Details are given on optical and infrared technology research directed toward developing advanced optical systems for guidance, tracking, and communication in aerospace missions. Component and device studies center on laser sources, detectors, modulators, beam scanners, and ring lasers. Communication and tracking techniques, involving superheterodyne receiver and frequency stabilization, are also being developed for use in particular systems. Theoretical and experimental studies on atmospheric effects in optical tracking and communication are reported, and progress on optical design, fabrication, and evaluation of components is outlined. The objectives of the optical technology satellite program are summarized, and a tentative list of the experiments chosen to simulate deep-space communication for ranges up to 160 million kilometers is included. E.A.O.

**N66-23458\*** National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

**LASER SYSTEMS RESEARCH AT MARSHALL SPACE FLIGHT CENTER**

Charles L. Wyman *In its Electron. Res. at MSFC* 1965 p 11-19 (See N66-23456 12-09) CFSTI: HC \$2.00/MF \$0.50

Two laser radar systems are described: an airborne optical guidance system for rendezvous maneuvers, and a ground based precision optical tracking system for advanced launch vehicles. The directional characteristics of lasers are briefly discussed, and basic range equations are presented. Characteristics of the prototype optical guidance system are given in tabular form. The system has both a long range laser source, and a fine range incoherent-light-emitting diode. Characteristics and requirements of the optical tracking system are summarized. It is concluded that the laser radar systems will offer greatly increased range and accuracy, and the elimination of microwave ground clutter and backscatter problems. E.A.O.

**N66-23584#** Toronto Univ. (Ontario), Dept. of Physics.  
**STIMULATED RAMAN EMISSION AND ABSORPTION SPECTROSCOPY** Status Report

B. P. Stoicheff Sep. 1965 4 p  
 (Contract Nonr-5012(00))  
 (AD-626747) CFSTI: HC \$1.00/MF \$0.50

In studying angular dependence of stimulated anti-Stokes emission photographs taken of three anti-Stokes "rings" in diamond show good agreement between theory and observed angles. A 3.4 meter Ebert spectrograph was installed and is performing absorption coefficient measurements. The construction of an argon ion laser with 50 milliwatt power output, which operates at eight different wavelengths, is also reported. A.O.

**N66-23746\*** Tyco Labs., Inc., Waltham, Mass.  
**DEVELOPMENT OF CONTINUOUS, HIGH EFFICIENCY, ROOM TEMPERATURE, VISIBLE WAVELENGTH, SEMICONDUCTOR INJECTOR LASERS** Final Report [1966] 46 p

(Contract NAS8-11864)  
 (NASA-CR-74018) CFSTI: HC \$2.00/MF \$0.50 CSCL 20E

This study was undertaken to develop a semiconductor injection laser for continuous operation at room temperature in the visible wavelength range. From the study technology was developed which enables the preparation of fully mounted heat sunk diodes of alpha-SiC. A novel approach to contacting was developed which is applicable to devices intended either for rectification or electroluminescent application. It was demonstrated that impurity levels (presumably deep) introduced from solution during crystal growth play a significant role in the details of the electroluminescent properties of SiC. Both the spectral distribution and the efficiency of the radiational process are affected. Additions of Ti and Zr appear beneficial. It was also demonstrated that the attainment of high doping levels to minimize bulk resistances in the alpha-SiC diodes is not an insurmountable problem. R.N.A.

**N66-23765\*** Massachusetts Inst. of Tech., Cambridge, Physics Dept.

**DYNAMICS AND CHARACTERISTICS OF THE SELF-TRAPPING OF INTENSE LIGHT BEAMS**

E. Garmire, R. Y. Chiao, and C. H. Townes [1965] 12 p refs  
 (Grant NSG-330)

(NASA-CR-74030) CFSTI: HC \$1.00/MF \$0.50 CSCL 20E

This paper reports direct observation of the evolution of beam trapping in CS<sub>2</sub> in the simplest cylindrical mode.

The threshold, trapping length, change in index of refraction, and steady-state beam profile were found to be consistent with theoretical predictions calculated from the nonlinear refractive index due to the Kerr effect. It was demonstrated that a steady-state condition is asymptotically approached in which the beam collapses to a bright filament as small as 50 microns.

R.N.A.

**N66-23875#** Lexington Labs., Inc., Cambridge, Mass.

**VAPOR PHASE GROWTH OF RUBY MONOCRYSTALS**  
**Semiannual Technical Summary Report, 1 Jul. 1965-1 Jan. 1966**

Philip S. Schaffer Feb. 1966 35 p refs

(Contract Nonr-4574(00)-1; ARPA Order 306; Proj. Defender)  
 (AD-629154) CFSTI: HC \$3.60/MF \$0.50

The vapor phase growth technique was further developed for the growth of large, high purity, low strain ruby monocrystals for laser applications. Constant growth temperature and reactant gas flow rate control units were incorporated into the crystal growth system. Other modifications were made in the growth system which permitted longer continuous runs than had been previously achieved. Ruby crystals were grown up to a weight of 96.3 grams in 58 hours. Some of the variables affecting the formation rate of chromium chloride were investigated. Some causes of gas inclusion-type defects were isolated and crystals were grown defect-free. Vapor-grown substrates were prepared from large crystals. A cylindrical ruby rod was fabricated without annealing from the 96.3-gram crystal. A threshold energy of 24.9 joules input was measured. Twyman-Green interferometry showed one fringe in the vapor-grown rod. Electron-beam microprobe analysis over the cross-section of the 96.3 gram crystal showed a chromium concentration deviation of  $\pm 8.77\%$  or  $\pm 5$  ppm.

Author (TAB)

# 1965

## IAA ENTRIES

**A65-14113 \***

A 4-MM-WAVELENGTH MOLECULAR GENERATOR WITH A FABRY-PEROT TYPE OF RESONATOR [O MOLEKULIARNOM GENERATORE NA VOLNE  $\lambda = 4$  MM S REZONATOROM TIPA FABRI-PERO].

A. F. Krupnov and V. A. Skvortsov (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorki, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 47, Nov. 1964, p. 1605-1611. 15 refs. In Russian.

Qualitative interpretation of the form of a spectral line observed in experiments with a beam of active molecules. The beam is studied with the use of a Fabry-Perot resonator, applying different types of oscillations. A maximum oscillation parameter is reached at an intermirror distance of  $\lambda/2$  with the oscillation type which yields a single maximum in the power field. The Stark effect arising during the  $10_1-0_{00}$  transition of a  $\text{CH}_2\text{O}$  molecule is investigated, and a molecular generator, adaptable to within  $\sim 10^{-7}$  cps by the Stark effect, is discussed. V.Z.

**A65-14131 \***

INVESTIGATION OF A "SPARK" IN THE AIR ARISING DURING FOCUSING LASER RADIATION [ISSLEDOVANIIE "ISKRY" V VOZDUKHE, VOZNIKAUSHCHEI PRI FOKUSIROVANIIE IZLUCHENIIA LAZERA].

S. L. Mandel'shtam, P. P. Pashinin, A. V. Prokhorov, A. M. Prokhorov, and N. K. Sukhodrev (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 47, Nov. 1964, p. 2003-2005. 7 refs. In Russian.

Results of an investigation of the spark, analogous to a breakthrough in gases, which is observed in the lens focus, with pulses of a certain critical strength and above, when the radiation of a laser with a modulated Q-factor is focused. A ruby quantum generator with a pulse-activated Q-factor is used to generate powerful pulses. The luminescence and dynamics of the spark are examined with the use of an SFR-2 high-speed photorecorder. The total energy released by the discharge, and the spark temperature are determined. The procedures are described and the results are discussed. V.Z.

**A65-14134 \***

QUANTUM PARAMAGNETIC AMPLIFIER WITH COUPLED ACTIVE RESONATORS, OPERATING ON A WAVELENGTH  $\lambda = 21$  CM [KVANTOVYI PARAMAGNITNYI USILITEL' SO SVIAZANNYMI AKTIVNYMI REZONATORAMI NA VOLNE  $\lambda = 21$  CM].

R. M. Martirosian and A. M. Prokhorov.

*Radiotekhnika i Elektronika*, vol. 9, Dec. 1964, p. 2094-2098. 5 refs. In Russian.

Experimental investigation of the characteristics of a maser amplifier operating at a frequency of 1420 Mc and using two coupled resonators containing an active paramagnetic substance. It is shown that a substantial increase in gain-bandwidth product can be obtained as compared to a two-resonator system using a passive input circuit. An investigation of the stability of the amplification factor also reveals the superiority of the active-type device. The experimental results obtained are found to be in good agreement with theory. V.P.

**A65-14137 \***

TRANSMISSION BAND OF A MULTIRESONATOR QUANTUM PARAMAGNETIC AMPLIFIER [POLOSA PROPUSKANIIA MNOGOREZONATORNOGO KVANTOVOGO PARAMAGNITNOGO USILITELIA].

V. B. Shteinshteyger and G. S. Misexnikov.

*Radiotekhnika i Elektronika*, vol. 9, Dec. 1964, p. 2099-2104. 8 refs. In Russian.

Discussion of a maser amplifier in the form of series-coupled resonators containing an active paramagnetic substance, with independent decoupling of the resonators. The bandwidth of the device is examined as a function of the number of resonators which it incorporates and the degree of independence of decoupling. V.P.

**A65-14144 \***

NONSTEADY-MODE STABILIZATION IN A TWO-LEVEL MASER [STABILIZATSIIA NEUSTOICHIVOGO REZHIMA V DVUKHROVNEVOM KVANTOVOM GENERATORE].

A. S. Agabekian, A. Z. Grasiuk, I. G. Zubarev, V. I. Svergun, and A. N. Oraevskii.

*Radiotekhnika i Elektronika*, vol. 9, Dec. 1964, p. 2156-2165. 6 refs. In Russian.

Discussion of the means of stabilizing the self-pulsed modulation mode of a two-level maser. Two methods are considered: (1) stabilization by applying an external signal of constant or slowly varying amplitude and (2) stabilization by introducing negative feedback with respect to resonator figure of merit. It is shown that, under some definite and practically possible values of the external force and the negative-feedback coefficient, the self-pulsed modulation mode can be stabilized without any appreciable change in maser emissivity. V.P.

**A65-14184**

POLARIZATION-OPTICAL TEMPERATURE MEASUREMENT AND FILTERING IN RUBY LASERS [POLARISATIONSOPTISCHE TEMPERATURMESSUNG UND FILTERUNG BEI RUBIN-LASER].

Hans-Georg Häfele (OSRAM GmbH Studiengesellschaft, Augsburg, West Germany).

*Zeitschrift für Naturforschung*, vol. 19a, Dec. 1964, p. 1353-1356. 8 refs. In German.

Optical measurement of the temperature of a homogeneous laser ruby by placing it between two crossed polarizers and by determining the spectral position of the polarization-interference bands. In the region of R-line fluorescence, the interference bands are shifted between 18 and 32°C with a temperature toward shorter wavelengths,  $\Delta\lambda/\Delta T = -0.83 \text{ Å/grad}$ . When the ruby is excited by a rod-shaped Xe-flash tube in an elliptical reflector, the threshold value of the temperature is increased by 1.1°C, and when a helix-shaped tube is used, the crystal temperature is increased by 3.1°C. While in the case of the rod-shaped tube the temperature after excitation drops to the ambient temperature in about 10 min, in the case of the helical tube it increases appreciably due to the heat conductivity from the hot quartz spiral. It is shown that the quality of a laser can be arbitrarily varied in the adjoining spectral regions by means of a simple polarization-interference filter. J.R.

**A65-14185**

HIGH-SYMMETRY OSCILLATION TYPES IN A CONTINUOUS WATER-COOLED LASER WITH NEODYMIUM IN CALCIUM TUNGSTATE [SCHWINGUNGSTYPEN HOHER SYMMETRIE BEIM KONTINUIERLICHEN WASSERGEKÜHLTEN LASER MIT NEODYM IN CALCIUMWOLFRAMAT].

K. Gürs and H. Westermeyer (Siemens und Halske AG, Forschungslaboratorium, Munich, West Germany.).

*Zeitschrift für Naturforschung*, vol. 19a, Dec. 1964, p. 1357-1362. 13 refs. In German.

Investigation of some high-symmetry oscillation systems similar to those occurring in gaseous lasers. Such oscillation types occur in the case of constant pumping (continuous laser) and application of optically very homogeneous crystals. It is shown that, in the case of good crystals, oscillation types of various orders are formed in one and the same crystal, depending on the excitation conditions. Nodal surfaces of natural oscillations are defined through residual disturbances in the crystal. J.R.

## A65-14215

### A65-14215 \*

#### EXPERIMENT ON THE CONSTANCY OF THE VELOCITY OF ELECTROMAGNETIC RADIATION.

Petr Beckmann and Peter Mandics (Colorado, University, Dept. of Electrical Engineering, Boulder, Colo.).  
*Journal of Research, Section D - Radio Science*, vol. 68D, Dec. 1964, p. 1265-1268. 20 refs.  
Research supported by the University of Colorado.

Repetition, using the coherent light of a laser, of an experiment by Kantor. Although Kantor reported results in sharp contradiction to Einstein's Second Postulate, the present results are found to be consistent with the Special Theory of Relativity. It is concluded that the ballistic hypothesis of light propagation disregarding the effect of air is incorrect. It is pointed out that the direct experimental evidence in favor of Einstein's Second Postulate is surprisingly meager and further experiments to confirm or reject the ballistic hypothesis are envisaged. (Author) D. H.

### A65-14345

#### A TRAVELING-WAVE PHOTO-ELECTRIC DEMODULATOR FOR USE IN LASER COMMUNICATIONS.

Shigebumi Saito, Yoichi Fujii (Tokyo, University, Institute of Industrial Science, Tokyo, Japan), Tadakuni Fujii, Akio Saburi, Takao Ando, and Hiromitsu Shiraki (Nippon Electric Co., Ltd., Communication Research Laboratory, Kawasaki, Japan).  
IN: INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, 5TH, TOKYO, JAPAN, SEPTEMBER 2-7, 1963, PROCEEDINGS. [A65-14290 05-31]  
Edited by Tsuyoshi Hayashi.

Tokyo, AGNE Corp., 1964, p. 737-744. 6 refs.

Description of the design and construction details of a laser demodulator using a helix traveling-wave tube with a photoelectric cathode. In contrast to Forrester's experiment, which uses a cavity resonator, the helix was tried because of its wideband characteristic. The tube is similar to one initiated by Siegman and his colleagues. The results of a series of preliminary experimental investigations of several different types of photoelectric cathode materials under intense incident light are described. Demodulation tests using a ruby laser were performed by detecting beat signals between different axial modes of the laser. A comparison is made with other methods of laser demodulation, and the results are shown graphically. M. M.

### A65-14617 \*

#### RADIATION FLUCTUATIONS IN OPTICAL QUANTUM GENERATORS ON A PULSE REGIME [PRO FLUKTUATSI V PROMINIUVANNIA OPTICHNOGO KVANTOVOGO GENERATORA V IMPUL'SNOMU REZHIMI].

V. L. Broude, O. M. Pogorelii, M. S. Soskin, B. V. Stetsenko, and O. F. Iatsenko (Akademiia Nauk Ukrain'skoi RSR, Institut Fiziki, Kiev, Ukrainian SSR).  
*Ukrains'kii Fizichnii Zhurnal*, vol. 9, Nov. 1964, p. 1267, 1268. 6 refs. In Ukrainian.

Discussion of the error that may arise in comparing basic laser emission with secondary emission, due to harmonic generation or combination scattering, when the harmonic is generated in one end of the laser and the resulting secondary emission is measured in the other end. Recommendations are given as to how to avoid the error. V. Z.

### A65-14621

#### LASERS AND LASER MATERIALS.

K. Nassau (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).  
(International Conference on Materials, Philadelphia, Pa., Feb. 3-6, 1964.)  
*Materials Research and Standards*, vol. 5, Jan. 1965, p. 3-11. 37 refs.

Survey of laser theory and laser materials. The desirable laser characteristics deduced from the equation for the condition for the onset of laser action are outlined, and the importance of this equation in the search for new laser materials is noted. The principal laser materials (gases, crystals, semiconductors, and glasses) are discussed, and the various types of lasers are evaluated. The chemical and physical properties of laser materials are described, and problems arising in the testing of new materials are examined. V. P.

### A65-14678 \*

#### SOME FURTHER ASPECTS OF LABORATORY ASTROPHYSICS AND SPACE SCIENCE.

H. I. S. Ferguson and R. W. Nicholls (Western Ontario, University, Dept. of Physics, London, Ontario, Canada).  
(Canadian Aeronautics and Space Institute, Astronautics Symposium, Montreal, Canada, Feb. 28-Mar. 1, 1963, Paper.)  
*Canadian Aeronautics and Space Journal*, vol. 10, Dec. 1964, p. 309-312. 11 refs.  
Grants No. N&G 349; No. AF AFOSR 62-236 A; Defence Research Board of Canada Contract No. MM 69-300002; Contract No. AF 19(628)-2820.

Part of a review of the current activities of the research program in laboratory astrophysics being conducted at the University of Western Ontario. It deals with work on laser excitation of powdered solids, studies of the passage of ionizing radiation through matter, and the plasma jet facility. It is stated that, while the first of these is a transient phenomenon, the last two are not and so can be examined spectroscopically over any reasonable time period, dependent upon the light available. It is concluded that very severe deficiencies in our knowledge of atomic and molecular processes had left the astronomer and astrophysicist with nothing quantitative to relate to their observations, until the rapid post-war growth of interest in the upper atmosphere and in the space outside it made such programs as have been described imperative. M. M.

### A65-14683 \*

#### ON THE OBSERVATION OF THE UPPER ATMOSPHERIC CONSTITUENTS BY LASER BEAMS.

Motokazu Hirono.

*Radio Research Laboratories, Journal*, vol. 11, July 1964, p. 251-271. 25 refs.

Review of formulas necessary to obtain precise observations of Rayleigh and Mie scattering, including consideration of the use of a radar equation. Methods of detecting very weak signals received from scattered echoes are considered, and it is shown that the photoelectron counting method is most suitable. The theoretical upper limit of giant pulses is calculated, and the possibility of making ionospheric observations with a powerful laser presently available is examined. It is shown that the time of observation of the scattering layer at a height of about 100 km by optical radar may be reduced to less than 0.1 sec with an SNR of 10. A proposal is made for observation of atmospheric constituents by resonance scattering of various wavelengths of strong beams at night. The first example is the resonance scattering of giant pulses of 9180-Å radiation (produced by a neodymium-doped-glass laser) from the  $N_2^+$  Meinel (1-0) band. Since the  $N_2^+$  ions in the ionosphere seem to be occasionally increased (during geomagnetic disturbances or changes in the  $E_s$  layer), it is thought that it should be possible to detect them during such an increase. It is also noted that if a powerful laser operating at 3914 Å is invented, it will be better to use this wavelength for detection. The second example is the resonance scattering of 7665-Å Raman laser beams from potassium atoms injected into the ionosphere artificially or occurring there naturally. It is believed that this method will give important information on the general atmospheric circulation or on wind systems. It is also shown that the vertical distribution of water vapor may be determined by 9180-Å laser beams or by ruby laser beams thermally tuned to the  $H_2O$  absorption line. (Author) D. H.

### A65-14674

PROPOSAL TO PRODUCE HYPERSONIC WAVES BY THE BRILLOUIN EFFECT UNDER THE SIMULTANEOUS ACTION OF TWO COHERENT LUMINOUS SHEAVES ON A SOLID OR LIQUID DIELECTRIC MEDIUM [PROPOSITION DE PRODUCTION D'ONDES HYPERSONORES PAR EFFET BRILLOUIN SOUS L'ACTION SIMULTANEE DE DEUX FAISCEAUX LUMINEUX. COHERENTS SUR UN MILIEU DIELECTRIQUE SOLIDE OU LIQUIDE].

Alfred Kastler (Ecole Normale Supérieure, Laboratoire de Physique, Paris, France).

*Académie des Sciences (Paris), Comptes Rendus*, vol. 259, no. 23, Dec. 9, 1964, p. 4233-4236. 10 refs. In French.

Discussion of experiments with the Brillouin effect. It is suggested that hypersonic waves can be generated in a liquid or crystalline medium by superposing on it two luminous sheaves of slightly different frequencies, with adequate polarization and by making an adjustable angle between them.

F. R. L.

**A65-14934**

A NEW VELOCITY SENSING TECHNIQUE USING LASER LIGHT.  
G. Stavits (General Precision, Inc., General Precision Aerospace Group, GPL Div., Pleasantville, N. Y.).

IN: ANNUAL EAST COAST CONFERENCE ON AEROSPACE AND NAVIGATIONAL ELECTRONICS, 11TH, BALTIMORE, MD., OCTOBER 21-23, 1964. TECHNICAL PAPERS. [A65-14925 05-21] Conference sponsored by the Institute of Electrical and Electronics Engineers, Baltimore Section, and Aerospace and Navigational Electronics Group.

North Hollywood, Western Periodicals Co., 1964, p. 1.3.5-1 to 1.3.5-10.

Description of a novel instrumentation developed to measure the relative velocity between a vehicle carrying a laser and a diffuse surface, based on the behavior and nature of the laser light when it is backscattered from the surface. The feasibility of the concept is experimentally demonstrated, and an analytical model of the phenomenon used is verified. Very high accuracy and reliability are shown to be implicit in the simplicity of the instrumentation.

(Author) J. R.

**A65-15103**

TRANSIENT PHENOMENA IN Q-SWITCHED LASERS - EXPERIMENTAL AND THEORETICAL ANALYSIS.

F. T. Arecchi, G. Potenza, and A. Sona (Centro Informazioni Studi Esperienze, Laboratori, Milan, Italy).

Nuovo Cimento, vol. 34, Dec. 16, 1964, p. 1458-1472. 13 refs. Research supported by the Consiglio Nazionale delle Ricerche.

Investigation of a rotating-prism, Q-switched laser to reveal the effect of various parameters on the number of giant pulses per flash, and on the time profile and peak power of the giant pulses. For a controlled temperature and a given reflectance of the mirrors (close to optimum), the dependence of the output characteristics is explored as a function of the following input parameters: cavity length, prism revolution period, time delay between the firing of the flash lamp and the parallel state of the reflector, and pump energy. It is found that a rate-equation treatment can give a good approximation to the dynamics of the Q-switched laser, at least up to the limit of 40% relative inversion. The theoretical results are in good agreement with experiment and permit the derivation of a similarity rule, connecting cavity length and reflector velocity, that can greatly simplify the design of Q-switched systems.

W. M. R.

**A65-15205 #**

TEMPERATURE DEPENDENCE OF THE FREQUENCY AND EMISSION OF THE  $R_1$  RUBY LINE [TEMPERATURNAYA ZAVISIMOST' CHASTOTY I SHIRINY IZLUCHENIA LINII  $R_1$  RUBINA]. M. E. Movsesian and Iu. S. Chilingarian (Erevanskii Gosudarstvennyi Universitet, Yerevan, Armenian SSR). *Akademiia Nauk Armianskoi SSR, Doklady*, vol. 39, no. 4, 1964, p. 217-219. In Russian.

Experimental investigation of the shift in the maximum fluorescence of the  $R_1$  ruby line as a function of temperature. Temperature variations are compared with variations in the maximum of the induced emission. It is found that there is a strong broadening of this line with increasing temperature. The frequency shift of the induced emission due to temperature is shown to be in good agreement with that of the maximum luminescence.

J. R.

**A65-15320**

MICROWAVE ELECTRON CYCLOTRON RESONANCE PUMPING OF A GAS LASER.

S. A. Ahmed and R. Kocher (Radio Corporation of America, Defense Electronic Products, Astro-Electronics Div., Princeton, N. J.).

IEEE, Proceedings, vol. 52, Dec. 1964, p. 1737, 1738. 5 refs.

Results of experiments on a new method of pumping gas lasers, applied to the He-Ne laser. Basically, the method is said to make use of the transfer of microwave power at the electron cyclotron resonance to raise the laser-plasma electron temperature in order to increase laser output. It is found that by coupling 2.45-Gc power

from a magnetron through an isolator, a directional coupler, and a stub tuner to a T-junction of a He-Ne laser, it was possible to increase the output power twofold over the output of the same laser pumped by conventional methods. If the magnetic field had extended over the entire 100-cm length of the laser tube instead of less than half of this length, a fivefold increase in output would presumably have occurred.

D. H.

**A65-15321**

THEORY OF EMISSION NOISE IN LASERS.

A. van der Ziel (Minnesota, University, Dept. of Electrical Engineering, Minneapolis, Minn.).

IEEE, Proceedings, vol. 52, Dec. 1964, p. 1738.

Army-supported research.

Derivation of an expression for the power density in the noise sidebands of a laser, caused by emission noise in the active medium. Except for a loss factor,  $\alpha$  (which may not be very important in gas lasers but must be taken into account in junction lasers), the expression is identical with an expression obtained by Gordon. This noise was recently detected by Prescott and van der Ziel in lasers operating near the threshold of oscillation. Far from this threshold, the noise drowns in the shot noise background of the photodetector.

D. H.

**A65-15323**

EVIDENCE OF STIMULATED EMISSION IN RUBY-LASER-PUMPED GaAs.

J. J. Schlickman, M. E. Fitzgerald, and R. H. Kingston (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).

IEEE, Proceedings, vol. 52, Dec. 1964, p. 1739, 1740. 5 refs.

Additional evidence of stimulated emission from the cleaved end surfaces of zinc-doped degenerate p-type GaAs crystals which were liquid-nitrogen cooled and irradiated by a spiking ruby laser. The phenomenon was characterized by a threshold ruby power above which the fluorescent emission from the cleaved (110) surface increased superlinearly with increasing ruby power while the highly polished (111) surface fluorescence increased only sublinearly. So far, Te-doped nondegenerate n-type GaAs has not shown evidence of stimulated emission while six zinc-doped samples with impurity concentrations ranging from  $8 \times 10^{18}$  to  $2 \times 10^{19} \text{ cm}^{-3}$  have. Better estimates are being sought of the quantum efficiency, of the added losses due to diffraction and surface scatter, and of the wave-propagation characteristics of this surface type of inversion layer.

D. H.

**A65-15324**

CROSS MODULATION OF GASEOUS LASERS BY HIGH-INTENSITY LIGHT.

B. Pariser and T. C. Marshall (Columbia University, Plasma Laboratory, New York, N. Y.).

IEEE, Proceedings, vol. 52, Dec. 1964, p. 1740, 1741.

Contract No. Nonr-266(93).

Description of a cross-modulation effect on the output of a 0.633- $\mu$  or 1.15- $\mu$  helium-neon type laser when the CW gaseous discharge in the latter is exposed to the strong broadband optical radiation of a flash tube. The flash pulse envelope is impressed upon the laser's signal, either increasing it or decreasing it according to the spectral distribution of the flash lamp's radiation. The effect is caused by the pumping of neon metastables in the gaseous discharge by optical absorption of the flash lamp radiation. An experiment to demonstrate the state-transition principles of the effect is described.

D. H.

**A65-15325**

MODE SUPPRESSION ON LASERS BY METAL WIRES.

Akira Okaya (Electro-Optical Systems, Inc., Pasadena, Calif.).

IEEE, Proceedings, vol. 52, Dec. 1964, p. 1741.

Description of mode suppression and mode stabilization experiments employing a standard 6328- $\text{\AA}$  He-Ne laser, 1.5 m in length, 8 mm in diam., and with mirrors of 1-m radius of curvature. Either single or crossed tungsten wires of 1 to 3 mils diameter were used as a mode discriminator by placing the wires in the laser beam between one Brewster window and the mirror. Among the modes produced at will by this method are:  $TEM_{12}$ ,  $TEM_{21}$ ,  $TEM_{22}$ , and  $TEM_{23}$ . The selective excitation of the  $TEM_{00}$  fundamental

mode was achieved by using a circular iris of radius  $a = (0.8b\lambda)^{1/2}$ , where  $b$  is the mirror separation and  $\lambda$  is the wavelength being excited. D.H.

#### A65-15326

##### GAIN SATURATION AND A METHOD OF SPECIFYING OUTPUT POWER CHARACTERISTICS OF A LASER TUBE.

T. Takahashi, T. Shigematsu, and K. Kakizaki (Tokyo Shibaura Electric Co., Ltd., Central Research Laboratory, Kawasaki, Japan).

IEEE, Proceedings, vol. 52, Dec. 1964, p. 1741, 1742.

Analysis of the relationships between laser gain, light power level, and the discharge current, including a proposal for a method of specifying output power characteristics of a laser tube. Curves are presented for: gain parameter vs light power; net gain of laser tube vs light power for various values of discharge current; net gain of laser tube vs discharge current for various values of light power; and steady-state light power within the cavity vs discharge current for various values of cavity loss. It is suggested that the latter curves enable one to estimate the output power of a laser when the loss and transmittance of each mirror are given; some errors may occur when mirror configurations other than the one used are employed. The configuration described used a pair of identical mirrors with a radius of curvature of 1.2 m, separated by a distance of 1.3 m. D.H.

#### A65-15327

##### A SOLID-STATE ROOM-TEMPERATURE OPERATED GaAs LASER TRANSMITTER.

G. F. Dalrymple, B. S. Goldstein, and T. M. Quist (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).

IEEE, Proceedings, vol. 52, Dec. 1964, p. 1742, 1743.

Description of the circuitry, mechanical construction details, and preliminary performance of a GaAs laser transmitter which, except for the power supply, can be built into a small self-contained unit and which can operate at room temperature. The transmitter employs a p-n-p-n transistor as a current switch and a Zn-diffused, Te-doped GaAs crystal as the lasing element. Output power from one end of the laser junction is 4 watts for an input current of 100 amps. Using integrated-circuit techniques, it should be possible to build a complete room-temperature, solid-state, pulsed laser transmitter (excluding the power supply) on a transistor header. D.H.

#### A65-15349 #

EFFECT OF FOG ON THE RANGE OF GROUND COMMUNICATIONS USING AN OPTICAL CARRIER WAVE [O VLIANII TUMANA NA DAL'NOST' NAZEMNOI SVIAZI NA OPTICHESKOI NESUSHCHEI]. S. P. Erkovich, Iu. V. Pisarevskii, F. S. Ageshin, and G. A. Tregubov.

Elektrosvyaz', vol. 18, Dec. 1964, p. 16-21, 6 refs. In Russian.

Discussion of methods for calculating the range of laser-based communications systems operating in a foggy open atmosphere. Light absorption and scattering in the atmosphere are analyzed as factors of primary importance. Literature sources on the behavior of water droplets in the atmosphere are quoted. Smolukhovskii's equations for asymptotic distribution of coagulating particles are evaluated as to their applicability to the problem. The possibility of laser-based communications systems operating in fog is indicated. V.Z.

#### A65-15438

##### MOLECULAR SCATTERING OF RUBY-LASER LIGHT.

T. V. George, L. Goldstein, L. Slama, and M. Yokoyama (Illinois, University, Gaseous Electronics Laboratory, Urbana, Ill.).

Physical Review, 2nd Series, vol. 137, Jan. 18, 1965, p. A369-A380, 15 refs.

USAF-Army-supported research.

Study of Rayleigh scattering with the aid of a ruby laser operating at 6943 Å. The angular distribution of light scattered by gas molecules was measured from 45° to 135° from the direction of the incident beam in argon and xenon. The experiment was conducted both in the plane of polarization of the incident laser beam and in the plane perpendicular to it. Absolute values of the differential-scattering cross section are determined for neon,

argon, xenon, oxygen, nitrogen, air, carbon dioxide, sulphur hexafluoride, and propane at NTP. The experimental results obtained with noble gases are compared with Rayleigh's theory. It is found that the ruby-laser light beam is not scattered isotropically either by argon or by xenon as predicted by the linear theory, in the plane perpendicular to the plane of polarization. In the plane of polarization, the scattered intensity appears to be consistent with a cosine-squared distribution. The measured differential-scattering cross sections for noble gases at 60° are found to be approximately twice as large as the theoretical values. (Author) D.H.

#### A65-15443

##### MECHANISM OF ELECTRON EMISSION PRODUCED BY A GIANT-PULSE LASER.

J. F. Ready (Honeywell, Inc., Research Center, Hopkins, Minn.). Physical Review, 2nd Series, vol. 137, Jan. 18, 1965, p. A620-A623, 13 refs.

Use of a spinning-prism Q-switched ruby laser with a peak power output of 2 Mw to produce single pulses of electron emission about 100 nsec long. Pulses of the order of hundreds of ma/cm<sup>2</sup> were emitted from well-cleaned tungsten, thoriated tungsten, and platinum targets in a hydrogen atmosphere at  $3 \times 10^{-8}$  torr. The mechanisms for production of the electrons were investigated. No component attributable to multiphoton or other nonlinear processes was identified. The amplitudes and shapes of the electron pulses agree with calculated values based on the assumption that all the electron emission is produced by conventional thermal effects. (Author) D.H.

#### A65-15458 #

##### ANGULAR OSCILLATION MODES IN A GASEOUS LASER [UGLOVYE TIPI KOLEBANIY V GAZOVOM OPTICHESKOM KVANTOVOM GENERATORE].

I. M. Belousova, O. B. Danilov, and B. A. Ermakov (Gosudaistvennyi Opticheskii Institut, Leningrad, USSR).

Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 47, Dec. 1964, p. 2013-2018, 6 refs. In Russian.

Investigation of the spectrum of difference frequency oscillations occurring in a neon-helium gaseous laser with plane parallel mirrors. It is found that there are several beat frequencies. The beat frequencies obtained are identified as difference frequencies between the basic and angular oscillation modes with the least indices inherent in the resonator considered. J.R.

#### A65-15460 #

##### TRANSITION PROCESSES IN RF THREE-LEVEL MASERS [PEREKHODNYE PROTSESSY V KVANTOVYKH TREKHUROV-NEVYKH GENERATORAKH RADIODIAPAZONA].

A. A. Manenkov, R. M. Martirosian, Iu. P. Pimenov, A. M. Prokhorov, and V. A. Sychugov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 47, Dec. 1964, p. 2055-2063, 16 refs. In Russian.

Experimental and theoretical investigation of the process of oscillation amplitude formation in rf three-level masers. Experiments are conducted with two types of masers in which ruby and rutile crystals containing Cr<sup>3+</sup> ion admixtures are used as active material. The masers considered have emitted at wavelengths of 21 cm and 10 cm, respectively. In the case of pulsed pumping, a transition process consisting of amplitude damped oscillations and a subsequent exponential approach to continuous operation is observed in both masers. The theoretical analysis of the transition processes is carried out on the basis of kinetic equations within the framework of the three-level system. Solution of these equations in the linear approximation is obtained in the analytical form. Formulas are also derived for determining the time lag between the beginning of emission and the beginning of pulsed pumping. The theoretical calculations are shown to be in good agreement with experimental data. J.R.

#### A65-15508 #

##### THEORY OF LIGHT-WAVE FREQUENCY CONVERSION BY A CRYSTAL [K TEORII PREOBRAZOVANIYA CHASTOTY SVETOVYKH VOLN KRISTALLOM].

B. V. Bokut' and A. G. Khatkevich (Akademiia Nauk Belorusskoi SSR, Institut Fiziki, Minsk, Belorussian SSR).  
Akademiia Nauk BSSR, Doklady, vol. 8, Nov. 1964, p. 713-716.  
 5 refs. In Russian.

Discussion of the possible types of polarization waves created by two light waves of different frequency incident upon a laser crystal. The electromagnetic inhomogeneous wave harmonics generated by these light waves are examined. It is shown that, using Fedorov's sequentially invariant method, it is possible to obtain a solution in explicit form, valid for all cases. V. P.

#### A65-15535

"MATCHED" PLASMA HEATING MODE USING LASER RADIATION.  
 O. N. Krokhin (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).  
Zhurnal Tekhnicheskoi Fiziki, vol. 34, July 1964, p. 1324-1327.  
Soviet Physics - Technical Physics, vol. 9, Jan. 1965, p. 1024-1026. Translation.

[For abstract see Accession no. A64-23691 19-24]

#### A65-15699

BRILLOUIN SCATTERING IN LIQUIDS EXCITED BY THE HE-NE MASER.

R. Y. Chiao (Massachusetts Institute of Technology, Cambridge, Mass.) and B. P. Stoicheff (National Research Council, Ottawa, Canada).

Optical Society of America, Journal, vol. 54, Oct. 1964, p. 1286, 1287. 7 refs.  
 Grant No. NSG 330; Contract No. AF 19(628)-4011.

Investigation of the Brillouin scattering in several liquids excited with the 6328-Å radiation of a He-Ne maser, using a high-resolution Fabry-Perot interferometer with photographic as well as photoelectric detection. These experiments led to a precise determination of velocities of acoustic waves in the hypersonic frequency range, and are considered to have demonstrated line broadening in the Brillouin spectrum for the first time. It is further considered that additional investigation of linewidths in Brillouin spectra, and their dependence on scattering angle and incident frequency, will be important in the study of relaxation processes, especially very fast chemical reactions, thus extending the work at ultrasonic frequencies.

F. R. L.

#### A65-15788

NANOSECOND HEATING OF AQUEOUS SYSTEMS BY GIANT LASER PULSES.

H. Staerk and G. Czerlinski (Pennsylvania, University, Johnson Research Foundation, Philadelphia, Pa.).

Nature, vol. 205, Jan. 2, 1965, p. 63, 64.  
 Contract No. Nonr-551(46).

Demonstration of the heating of some pH-indicator systems within a few nsec. The heating pulse was generated by a TRG model 104 laser, using a ruby crystal. Two pulses were generally obtained at full output (together 1 joule), about 100 nsec wide and 200 nsec apart, inherent to Q-switches operating with rotating prisms. Experiments were performed on aqueous solutions containing: (1)  $\text{CuSO}_4$ , bromthymol blue and triethanolamine, and (2) methylene blue, bromthymol blue, and glycylglycine. Oscilloscope traces of the experiments are presented.

F. R. L.

#### A65-15801 \*

MASER ACTION BY POPULATION INVERSION IN A MOLECULAR BEAM.

G. Schulten (Philips Zentrallaboratorium GmbH, Hamburg, West Germany).

Philips Research Reports, vol. 19, Aug. 1964, p. 395-399.

Method for obtaining an inversion of the normal Boltzmann distribution in a molecular beam at frequencies in the millimeter range or higher. The beam passes a pump field, the frequency of which is equal to the transition frequency of a two-level system. Under certain conditions, the molecules leave the pump field with an excess population in the upper level. It is seen to be possible to construct a molecular beam maser in the millimeter region by using a rotational transition of a linear molecule such as OCS.

(Author) W. M. R.

#### A65-15806

THE EXISTENCE OF EIGENVALUES FOR THE INTEGRAL EQUATIONS OF LASER THEORY.

J. Alan Cochran (Bell Telephone Laboratories, Murray Hill, N.J.).  
Bell System Technical Journal, vol. 44, Jan. 1965, p. 77-88.  
 15 refs.

Investigation of the general integral equations governing the mode spectra of optical masers from the standpoint of certain theoretical results for Hölder continuous kernels. Using an estimate originally performed by Fredholm, it is proved that the homogeneous integral equation  $\phi(x) = \lambda \int K(x, y)\phi(y) dy$  has at least one eigenvalue for Hölder continuous kernels  $K$  with exponent  $\alpha > 1/2$ , and with nonvanishing trace. It is stated that all the integral equations which have been treated in laser theory so far can be "factored" into one-dimensional equations with continuously differentiable kernels, to which this result applies directly. Demonstrations of the nonvanishing character of the trace of several of the common "laser kernels" associated with practical reflector configurations are provided. It is pointed out that in almost all cases these results give the first rigorous proof of the existence of eigenvalues and eigenfunctions for the integral equations of the optical maser.

(Author) M. M.

#### A65-15816

LONG-TRANSIENT EFFECTS IN LASERS WITH INSERTED LIQUID SAMPLES.

J. P. Gordon, R. C. C. Leite, R. S. Moore, S. P. S. Porto, and J. R. Whinnery (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

Journal of Applied Physics, vol. 36, Jan. 1965, p. 3-8. 10 refs.

Observation of buildup and decay transients when polar or non-polar liquid cells are placed within the resonator of a helium-neon laser operating in the red at 6328 Å. Similar but smaller effects are also observed with two solids. Time constants are found to be of the order of a few seconds for all materials, which suggests a thermal phenomenon. However, general heating effects are ruled out by the strong localization of the phenomenon. Transverse motion of the cell by about one beamwidth is shown to cause new transients similar to the initial ones. It is believed that the effects are caused by absorption of the red light in the material, producing a local heating in the vicinity of the beam and a lens effect arising from the transverse gradient of refractive index. Absorptions of  $10^{-3}$  parts/cm are found to be sufficient to produce the effects, and are believed to be reasonable values for the materials studied. One of the most important applications is suggested for the measurement of small absorbencies. The experiments are described, and an analysis of the lens effect from absorption is given. Alternate explanations considered are stated briefly.

(Author) J. R.

#### A65-15819

PERFORMANCE OF THE He-Ne GAS LASER AS AN INTERFEROMETER FOR MEASURING PLASMA DENSITY.

D. E. T. F. Ashby, D. F. Jephcott, A. Malein, and F. A. Raynor (United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Culham Laboratory, Abingdon, Berks., England).

Journal of Applied Physics, vol. 36, Jan. 1965, p. 29-34. 9 refs.

Theoretical and experimental investigation of the characteristics of a He-Ne gas laser used in a new simple interferometric technique. The interferometer has two novel features: (1) the intensity of the laser itself is used to detect the fringes, and (2) because the intensities of the 0.63-μ (red) and 3.39-μ (infrared) laser beam are coupled, interference in the infrared can be detected by a simple photomultiplier monitoring the red beam. The system does not respond instantaneously to changes in the optical path length. Experimental measurements show that when the red beam is used to follow interference in the infrared, the maximum detectable response is limited to about  $3 \times 10^6$  fringes/sec. Discussion of the frequency response and the cross-coupling between the two wavelengths leads to the conclusion that the frequency response is limited by the red channel only. Experimental details of the interferometer are described, including the application of a multipass system which, with some loss in spatial resolution, increases the sensitivity of the interferometer by at least a factor of 20.

(Author) J. R.



## A65-15824

### A65-15824

#### GIANT PULSES FROM A LASER - OPTIMUM CONDITIONS.

M. Menat (Israel Atomic Energy Commission, Tel-Aviv, Israel). *Journal of Applied Physics*, vol. 36, Jan. 1965, p. 73-76. 6 refs.

Examination of the conditions for maximized peak power extraction from a giant pulse laser. In order to formulate an appropriate mathematical framework relating the various significant magnitudes, some simplifying assumptions and approximations are used. The critical coupling conditions and the value of the resulting optimum peak power as a function of a characteristic loss factor are determined. A distinction is made between maximum peak power and maximum energetic yield since the conditions for the achievement of both are slightly different.

(Author) J. R.

### A65-15838

#### EFFECT OF BACKGROUND GAS ON LASER-INDUCED ELECTRON EMISSION FROM METAL SURFACES.

N. R. Isenor (Waterloo, University, Dept. of Physics, Waterloo, Ontario, Canada). *Journal of Applied Physics*, vol. 36, Jan. 1965, p. 316, 317. 7 refs. Research supported by the National Research Council of Canada.

Description of an experiment in gas pressures between  $10^{-5}$  and  $10^{-3}$  torr conducted with a giant pulse ruby laser with an output of 0.05 J in a pulse of 50-msec duration. The emission current consisted of two components. It was found that the "prompt" component was almost coincident with, and very similar in duration to, the laser pulse. Its magnitude was proportional to background gas pressure. A slower component followed, first of negative and then of positive charge emission. This component was independent of gas pressure. The results indicate that laser-induced electron emission from zinc and tantalum surfaces is enhanced by absorbed gas.

J. R.

### A65-15838

#### QUADRUPLER FREQUENCY MULTIPLICATION OF A 1.06- $\mu$ NEODYMIUM-PULSED LASER.

Fred M. Johnson (Electro-Optical Systems, Inc., Pasadena, Calif.).

*Nature*, vol. 204, Dec. 5, 1964, p. 985-987. 6 refs. USAF-supported research.

Use of the nonlinear optic effect in two KDP crystals to produce the fourth harmonic of a Q-spoiled high-intensity neodymium-in-glass laser. The laser output pulse at 1.06  $\mu$  has been converted successively to 5300 Å and 2650 Å. The experimental arrangement is described and illustrated with a schematic diagram. Tabulated data include a summary of data on frequency quadrupling and a table of wavelengths and refractive indices. The results of the experiment are said to suggest possibilities of new coherent optical sources with powers in the kilowatt region and wavelengths in the UV region of the spectrum.

D. H.

### A65-15880

#### THE GENERATION OF HYPERSOUNDS BY SUPERPOSITION OF TWO COHERENT LIGHT BEAMS IN A SOLID OR LIQUID DIELECTRIC [SUR LA GENERATION D'HYPERSONS PAR SUPERPOSITION DE DEUX FAISCEAUX LUMINEUX COHERENTS DANS UN DIELECTRIQUE SOLIDE OU LIQUIDE].

Alfred Kastler (Ecole Normale Supérieure, Laboratoire de Physique, Paris, France).

*Académie des Sciences (Paris), Comptes Rendus*, vol. 259, no. 25, Dec. 21, 1964, p. 4535-4540. 5 refs. In French.

Presentation of a classic elementary theory to explain a method for obtaining a progressive hypersonic wave in a given direction by superposing in a dielectric medium two beams of coherent light which produce in it a system of moving interference fringes. The subjects considered are: (1) production of a moving system of light interference fringes, (2) electrostrictive wave produced by light, (3) differential equation of the forced elastic wave produced in the medium by the electrostrictive wave, (4) solution of the differential equation, (5) power consumed by the hypersonic wave, and (6) discussion of results and resonance phenomenon.

M. M.

### A65-15951 #

#### HIGHER ORDER OPTICAL MIXING OF RAMAN LASER LIGHT IN NONLINEAR DIELECTRIC MEDIA.

Tatsuo Yajima and Masamoto Takatsuji (Tokyo, University, Institute for Solid State Physics, Tokyo, Japan).

*Physical Society of Japan, Journal*, vol. 19, Dec. 1964, p. 2343, 2344.

Use of nitrobenzene Raman laser light to observe  $2\omega_R - \omega_{S1}$  and  $2\omega_R - \omega_{S2}$  light. The effect should be interpreted as resulting primarily from third order nonlinear polarization of the type  $P = X : EEE$  where E is the electric field of light. The Raman laser output was obtained from a Q-switched ruby laser using a nitrobenzene Kerr cell inside the cavity. The output consisted of the ruby line at 6943 Å and several Stokes lines (7659 Å and 8538 Å); peak powers were 1 Mw, 50 kw, and 100 watts. Materials examined were: quartz, ADP, and KDP; MgO, NaCl, KCl, KI, LiF; glass; and  $C_6H_6$ ,  $(C_2H_5)_2O$ ,  $CH_3OH$ ,  $CS_2$ ,  $H_2O$ , and  $C_6H_5NO_2$ .

D. H.

### A65-15995

#### AN INJECTION LASER PUMP FOR $Nd^{+3}$ DOPED HOSTS.

R. H. Harada and C. K. Suzuki (North American Aviation, Inc., Autonetics Div., Lasers and Electro-Optics Laboratories, Anaheim, Calif.).

*Applied Optics*, vol. 4, Feb. 1965, p. 225-227. 5 refs.

Description of a diode laser prepared from highly degenerate GaAs and emitting at wavelengths greater than 8700 Å. A laser diode emitting at about 8700 Å is desirable, since this wavelength matches the lowest absorption band of  $Nd^{+3}$ -doped lasers. An optical pump emitting at a single frequency matched to the lowest absorption band of a 3- or 4-level laser eliminates the adverse heating effects associated with flash lamp pumping, resulting in a considerable increase in the conversion efficiency.

(Author) A. B. K.

### A65-15998

#### GAS-LASER FREQUENCY SELECTION BY MOLECULAR ABSORPTION.

C. Bradley Moore (California, University, Dept. of Chemistry, Berkeley, Calif.).

*Applied Optics*, vol. 4, Feb. 1965, p. 252, 253. NSF-USAF-supported research.

Description of a gas-phase molecular absorption which can discriminate efficiently between two frequencies separated by little more than the Doppler linewidth of the molecular transition. This discrimination is made without introducing into the optical resonator any extra optics or losses at the frequency of the desired transition. The frequency of a helium-neon laser operating at the 2947.90-cm<sup>-1</sup> ( $3.3923\text{-}\mu$ )  $3s_2 - 3p_2$  transition was changed to the nearby frequency of the 2948.79-cm<sup>-1</sup> ( $3.3912\text{-}\mu$ )  $3s_2 - 3p_2$  transition by placing methane gas within the optical resonator. A power level at 2948.79 cm<sup>-1</sup> of over 40% of the normal power level at 2947.90 cm<sup>-1</sup> was achieved. This laser source of two close frequencies provides an extremely sensitive method of detecting methane.

A. B. K.

### A65-16129

#### MEASUREMENTS OF CAVITY LOSS IN A PULSED RUBY LASER.

D. Chen (Honeywell, Inc., Research Center, Hopkins, Minn.).

*Nature*, vol. 205, Jan. 16, 1965, p. 271, 272. 8 refs.

Measurement of cavity loss performed on a Linde sapphire-clad ruby laser rod in the range from 77°K to 293°K. The results obtained are very comparable to those measured at reduced temperature on other Linde ruby laser rods grown during the same period of time. The method described here eliminates the inaccuracy and difficulty due to the nonlinear property of the flashtube in the conventional laser cavity-loss measurements. Since measurements are made at relatively high pumping input, there is no need to search tediously for the threshold pumping energy. The results obtained indicate that the cavity loss is essentially constant over the temperature range investigated, and the assumed four-level system is an adequate description for the pulsed ruby laser.

A. B. K.

### A65-16267 #

#### A THEORY OF MICROWAVE MASERS IN STRONG PUMPING FIELD.

Yoshio Ebina (Tohoku University, Research Institute of Electrical Communication, Sendai, Japan).

*Physical Society of Japan, Journal*, vol. 19, Nov. 1964, p. 2195-2206. 16 refs.

Application of the rate equations of the spin density matrix, referred to a rotating coordinate system, to an investigation of the mixing between unperturbed spin states produced by a strong coherent pumping field at an angular frequency  $\omega$ . The relaxation of each state, usually introduced through phenomenological considerations, is obtained from an interaction Hamiltonian for the spin moments and local fields. Given a small-signal field at the frequency  $\omega$ , oscillations induced at  $2\omega \pm \omega_s$  and  $\omega_s$  can be made to emit or absorb power through an appropriate choice of pumping field. The components at  $2\omega \pm \omega_s$  are attributed to frequency mixing between  $\omega$  and  $\omega \pm \omega_s$ . For spin moment  $l \times \hbar$ , the emitted or absorbed line shape is not a simple Lorentzian and is considered to be a quantum effect in the three-level scheme. It is expected that the frequency of the emitted or absorbed field can be shifted by varying the static magnetic field or the magnitude or frequency of the pumping field. (Author) W.M.R.

#### A65-16282 #

THEORY OF MULTIRESONATOR SELECTIVE ALL-PASS QUANTUM AMPLIFIERS [TEORIYA MNOGOREZONATORNYKH SELEKTIVNYKH PROKHODNYKH KVANTOVYKH USILITELEY].

V. N. Alifiev and Iu. P. Pimenov.

Radiotekhnika i Elektronika, vol. 10, Jan. 1965, p. 45-53. 6 refs. In Russian.

Brief analysis of advanced masers, with particular reference to their use in radio receivers. Some results obtained from the general theory of all-pass wideband quantum amplifiers with several loops, having a high SNR and maximally flat frequency-response characteristics in the transmission band, are presented. V. P.

#### A65-16362

ABSORPTION OF 3.39-MICRON HELIUM-NEON LASER EMISSION BY METHANE IN THE ATMOSPHERE.

Byron N. Edwards and Darrell E. Burch (Philco Corp., Aero-nutronic Div., Newport Beach, Calif.).

Optical Society of America, Journal, vol. 55, Feb. 1965, p. 174-177. 7 refs.

Description of an experiment on the absorption of the  $3s_2-3p_4$  helium-neon laser emission at  $2947.903 \text{ cm}^{-1}$  by methane. The emission frequency coincides closely with one of the components of the  $P(F^+)$  branch of the  $\nu_3$  band of methane. Methane and nitrogen in different mixing ratios were introduced into an absorption cell, and the transmittance as a function of pressure was determined. By relating the measured absorption coefficient with the known interaction of collision and Doppler effects on the broadening of the absorption line, the separation of the emission line and the nearest absorption line was deduced to be  $0.003 \pm 0.002 \text{ cm}^{-1}$ . The collision-broadened full-width at half-maximum of the absorption line was determined to be  $0.13 \pm 0.04 \text{ cm}^{-1}$  at atmospheric pressure. At 1 atm in the Earth's atmosphere, the transmittance can be calculated to be  $T = \exp(-1.1 L)$  by using the published value of the concentration of methane, where  $L$  is the path length in kilometers. The effects of laser emission in several possible cavity modes and of several absorption lines in the methane group which overlap each other at high pressures are discussed. (Author) M.M.

#### A65-16382

LASER EXCITATION OF POWDERED SOLIDS.

H. I. S. Ferguson, J. E. Mentall, and R. W. Nicholls (Western Ontario, University, Dept. of Physics, London, Ontario, Canada). Nature, vol. 204, Dec. 26, 1964, p. 1295. 9 refs. Grants No. NSG 349; No. AF AFOSR 62-236A.

Brief review of spectroscopic investigations which have been made on laser excitation of molecular spectra from powdered solids in air. A table of molecular spectra produced for various materials is presented. The powdered solid target materials were found to be superior to nonpowdered solids because of their greater surface area, lower reflectivity, and lower thermal diffusivity. The strong preponderance of oxide band systems observed is consistent with the oxidizing atmosphere in which they were excited, and supports the belief that much of the molecular spectrum arises from chemical reactions in the flame. F.R.L.

#### A65-16385

INTERNAL MODULATION OF A GAS LASER AT 4000 MC [MODULATION INTERNE D'UN LASER A GAZ A 4000 MHz].

Nguyen Ngoc Chau (Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux, Seine, France).

Academie des Sciences (Paris), Comptes Rendus, vol. 260, no. 1, Jan. 4, 1965, p. 100-103. 5 refs. In French.

Experimental investigation of the internal modulation of a gas laser by means of a germanium photodiode inversely polarized and mounted in a coaxial circuit followed by a progressive-wave pre-amplifier tube, in turn followed by a hyperfrequency mixer and an amplifier with a 30-Mc intermediate frequency. It is stated that, compared to external amplitude modulation, internal modulation yields a gain higher than 20 db, all the other measurement conditions being otherwise identical, in particular, the modulation power at 4000 Mc which remains constant in the two cases, the same as the luminous power falling on the photodiode. M.M.

#### A65-16401

ON THE EFFICIENCY OF SINGLE AND MULTIPLE ELLIPTICAL LASER CAVITIES.

C. Bowness (Raytheon Co., Laser Advanced Development Center, Waltham, Mass.).

Applied Optics, vol. 4, Jan. 1965, p. 103-107. 6 refs.

Analysis of the relative efficiencies of single and multiple elliptical cavities for laser pumping. The efficiency of single, dual, triple, quadruple, and octuple cavities is presented in simple graphical form for a wide range of axial ratios and for lamps and crystals having relative diameters from one-half up to two to one. After carefully distinguishing the criterion of maximum efficiency from that of maximum power or energy output, the paper includes some discussion on the choice of an optimum design of a laser cavity. (Author) D.H.

#### A65-16402

OPTICAL PROPERTIES AND LASER THRESHOLDS OF THIRTY-NINE RUBY LASER CRYSTALS.

G. W. Dueker, J. G. Atwood (Perkin-Elmer Corp., Norwalk, Conn.), C. M. Kellington, and M. Katzmann (U.S. Army, Electronics Command, Electronics Laboratories, Fort Monmouth, N. J.).

Applied Optics, vol. 4, Jan. 1965, p. 109-118. 12 refs. Army-supported research.

Description of measurements made of optical path uniformity, chromium concentration, fluorescence linewidth, large-angle scatter, and laser threshold on 39 flame-fusion rubies. Results show that index of refraction variation is explainable by variation of chrome concentration and wander of the optic axis. Residual stress plays little role in optical defects, but may broaden the  $77^\circ\text{K}$  linewidth. Optical quality of lasers cut from regions of boules selected by interferometry remains constant after cutting, but warping destroys their parallelism. Threshold increases with chromium concentration, indicating that the rods are optically thick at the pumping bands. Threshold is not correlated with other optical properties, however. (Author) D.H.

#### A65-16403

BIDIRECTIONAL ELECTRICALLY SWITCHED LASER.

R. V. Pole, R. A. Myers, and J. Nuñez (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N. Y.).

Applied Optics, vol. 4, Jan. 1965, p. 119-121.

Investigation of the operation of a double-rooftop ruby laser emitting along directions that are at an angle of  $17.45^\circ$  with respect to one another. The ruby is a 3.17-cm cylinder with a  $17.45^\circ$  chisel at each end, one of which is silver-coated. The other end has an antireflection coating, so that external dielectric (or silver) reflectors complete two separate Fabry-Perot cavities, which have about one-third the active medium in common. A polarizer and nitrobenzene Kerr cell in each path allow fast switching from one axis of emission to the other; the switching has been accomplished within

## A65-16404

1  $\mu$  sec in the present experiment. Some implications of the experiment with regard to more general problems of laser deflection are also discussed.

(Author) D.H.

## A65-16404

### INTERNAL MODULATION OF OPTICAL MASERS - BANDWIDTH LIMITATIONS.

L. P. Kaminow (Bell Telephone Laboratories, Inc., Holmdel, N. J.).

Applied Optics, vol. 4, Jan. 1965, p. 123-127. 8 refs.

Brief review of the operation of coupling-type internal modulators, including an examination of bandwidth limitations. It is found that excitation of natural modes of the resonator will normally restrict the signal bandwidth to half the longitudinal mode spacing. However, the bandwidth can be extended if the maser is permitted to oscillate in only one mode, if only a small fraction of the internal energy is coupled out, and if large attenuation can be introduced at appropriate resonator mode frequencies.

(Author) D.H.

## A65-16405

### FREQUENCY SPECTRA OF He-Ne OPTICAL MASERS WITH EXTERNAL CONCAVE MIRRORS.

Teiji Uchida (Nippon Electric Co., Ltd., Radio Industry Div., Tokyo, Japan).

Applied Optics, vol. 4, Jan. 1965, p. 129-131. 6 refs.

Use of photomixing techniques and noise distribution measurement to obtain spectral measurements of gaseous optical masers. Particularly, it was verified that low-frequency beat components occur between spatially independent transverse modes of the same order. This was found in an experiment on mode control. Frequency-spread of beat components is also discussed.

(Author) D.H.

## A65-16406

### A HELIUM-NEON LASER AMPLIFIER.

L. E. S. Mathias and N. H. Rock (Services Electronics Research Laboratory, Baldock, Herts., England).

Applied Optics, vol. 4, Jan. 1965, p. 133-135. 7 refs.

Description of a helium-neon laser amplifier operating at 1.15  $\mu$ . A discharge tube of rectangular cross section was employed, allowing a large cross section of discharge without impairing its efficiency for laser action. The optical arrangement provided multiple transits of the signal beam through the discharge, enabling the use of long optical paths. A low-level gain of 400 and a saturation output power of 23 mw were obtained. The output power was limited by inefficient use of the discharge volume. The system was also operated as an oscillator and a pulsed amplifier.

(Author) D.H.

## A65-16407

### A "TWISTED-MODE" TECHNIQUE FOR OBTAINING AXIALLY UNIFORM ENERGY DENSITY IN A LASER CAVITY.

V. Evtuhov (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.) and A. E. Siegman (Stanford University, Electrical Engineering Dept. and Microwave Laboratory, Stanford, Calif.).

Applied Optics, vol. 4, Jan. 1965, p. 142, 143.

USAF-Army-supported research.

Outline of a method for achieving a standing wave with an axially uniform energy density in a laser cavity. The physical configuration consists of a high quality ruby rod with birefringent quarter-wave plates (conveniently made of sapphire) and two mirrors. The normal modes (axial modes) of the structure may be viewed as consisting of either right-handed or left-handed circularly polarized waves traveling right and left in the center section. Since two quarter-wave plates plus a mirror are equivalent to one full-wave plate, a right-handed wave (for example) still has its original polarization after two reflections and thus can "catch its tail" to complete the mode. The E-field mode pattern in the rod at an instant of peak E field has the shape of a twisted ribbon with a period of one optical wavelength; the structure is therefore referred to as a twisted-mode structure. Other properties

and two special cases are discussed. A note added in proof describes preliminary experiments with a twisted-mode structure having  $7\lambda/4$  plates; the assembly was pumped in a double-elliptical cavity, and the spectrum of the output was examined using a Twyman-Green interferometer. Single-frequency output was noted up to about 15% above threshold for certain azimuthal orientations of the assembly in the pumping cavity. The causes of this azimuthal dependence are being investigated.

D.H.

## A65-16565

### EIGHT-MILLIMETER TRAVELING-WAVE MASER AND MASER-RADIOMETER SYSTEM.

F. R. Arams and B. J. Peyton (Cutler-Hammer, Inc., Airborne Instruments Laboratory Div., Deer Park, N.Y.).

IEEE, Proceedings, vol. 53, Jan. 1965, p. 12-23. 40 refs.

USAF-supported research.

Description of a low-noise,  $K_a$ -band traveling-wave maser amplifier for the "window" at 8 mm, near 36 Gc, where atmospheric attenuation is remarkably low. The maser, which has chromium-doped rutile as the active material, is operated with push-pull pumping and is tracked with broadband, helium-cooled ferrite isolators to obtain a tuning range from 35.4 to 40 Gc. It has a noise temperature near 20°K, net gains of 20 db, and an instantaneous bandwidth of 75 Mc. Design considerations and measured electrical characteristics of the maser are presented, and its use to demonstrate a substantial sensitivity improvement in a radiometer system is described.

P.K.

## A65-16566

### A SELF-CONSISTENT FIELD ANALYSIS OF SPHERICAL-MIRROR FABRY-PEROT RESONATORS.

Peter O. Clark (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

IEEE, Proceedings, vol. 53, Jan. 1965, p. 36-41. 10 refs. Contract No. AF 19(604)-8052.

Presentation of a self-consistent field analysis for the field distributions of the resonant modes in an arbitrary two-mirror Fabry-Perot resonator with curved mirrors. The analysis leads to an integral equation for the field distributions. While this equation can be solved exactly for only the confocal cavity, in the limit of infinite Fresnel numbers, solutions are obtained for the general, nonsymmetric, nonconfocal resonator. With this approximation, the electric field anywhere within the resonator is described in terms of Hermite-Gaussian functions, and the resonance condition is obtained. The variations of nodal surface radii and characteristic mode dimensions are examined. Using a new definition of incremental mode volume, a minimum mode volume at a ratio of mirror separation to mirror radius of 1.5 is obtained, rather than at the confocal value of 1.0.

P.K.

## A65-16569

### THE EFFECT OF OPTICAL PUMP PULSE SHAPE ON RUBY INVERSION.

P. N. Mace and G. McCall (California, University, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.).

IEEE, Proceedings, vol. 53, Jan. 1965, p. 74.

AEC-sponsored research.

Study of the effect of optical-pump pulse shape on the population inversion attained in a ruby laser. For pump-light intensities of rectangular, ramp, quarter-cycle sine-wave, half-cycle sine-wave, and exponential shapes, the fractional inversion is plotted against energy for a 1-msec pulsewidth. The results indicate that little improvement in inversion levels can be obtained by shaping the pulse.

P.K.

## A65-16570

### BROADBAND DIELECTRIC MIRRORS FOR MULTIPLE WAVELENGTH LASER OPERATION IN THE VISIBLE.

D. L. Perry (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

IEEE, Proceedings, vol. 53, Jan. 1965, p. 76, 77. 5 refs.

Brief description of highly reflecting (> 99.5%) broadband dielectric mirrors covering the wavelength range 4300 Å to 7400 Å. The composite mirror, fabricated by refined evaporation techniques, consists of two stacks of 25 layers each, with the center wavelengths of the stacks spaced approximately 1500 Å apart. Cryolite was used for the low-index layers and ZnS powder for the high-index layers. A pair of these mirrors has been used with an experimental pulsed gas laser to observe laser oscillations at 28 wavelengths in the visible region. P.K.

## A65-16571

## THE OBSERVATION OF MODE IMPURITY IN GAS LASERS APPARENTLY RESONATING IN THE TEM-00 MODE.

H. M. Heinemann and H. W. Redlien, Jr. (Wheeler Laboratories, Inc., Laser Engineering Group, Smithtown, N.Y.).  
IEEE, Proceedings, vol. 53, Jan. 1965, p. 77, 78. 5 refs.

Description of mode impurity observed in diffraction measurements employing a gas laser apparently resonating in the TEM-00 mode. The presence of undesired higher modes is discussed, and their elimination through the use of accurately measured diffraction patterns and mirror realignment is described. P.K.

## A65-16574

## GAIN-DELAY CHARACTERISTICS OF A PULSED NEODYMIUM-GLASS LASER OSCILLATOR-AMPLIFIER CHAIN.

K. F. Tittel and J. P. Chernoch (General Electric Co., Advanced Technology Laboratories, Schenectady, N.Y.).  
IEEE, Proceedings, vol. 53, Jan. 1965, p. 82, 83. 11 refs.

Description of some of the operating characteristics of a four-level neodymium-doped glass-laser oscillator-power amplifier chain. This system permits frequency matching and good gain stability in the presence of temperature variations. A series of gain measurements was made to evaluate the optimum operating conditions. A plot of the amplifier output as a function of the oscillator trigger delay time for different oscillator output energies and amplifying pumping periods is presented, as are plots of the amplifier power gain as functions of pump energy and laser input energy. An optimum oscillator input delay time is found which is independent of amplifier pump and input energy, but which changes for different pump and input durations. P.K.

## A65-16575

QUASI-CONTINUOUS OPERATION OF A  $\text{CaWO}_4:\text{Nd}^{3+}$  MASER USING LONG DURATION PUMPING PULSES.

H. Manger (Karlsruhe, Technische Hochschule, Institut für Hochfrequenztechnik und Hochfrequenzphysik, Karlsruhe, West Germany).  
IEEE, Proceedings, vol. 53, Jan. 1965, p. 83, 84.

Description of pumping schemes for obtaining quasi-continuous maser operation, and which can be used with standard flash lamps, without cooling, and with maser crystals of less than optimum quality. The pumping light intensity and output signal for a 5-cm-long plane parallel  $\text{CaWO}_4:\text{Nd}^{3+}$  rod at room temperature, having dielectric coatings at both ends, are discussed. P.K.

## A65-16581

## ABSENCE OF POLARIZATION EFFECTS IN DIFFRACTION-ATTENUATED LASER LIGHT.

Reinhold Gerharz (U.S. Army, Engineering Research and Development Laboratories, Fort Belvoir, Va.).

IEEE, Proceedings, vol. 53, Jan. 1965, p. 105, 106. 8 refs.

Discussion of Stroke's objections to a proposal of the author for determining the energy of laser emissions by providing discrete steps of attenuation with the higher order steps of a diffraction grating. Stroke's objections relate to those possible errors in the intensity display of the higher order that could originate from a mismatch of orientation of the plane of polarization of the electric vector of the laser light and of the plane of dispersion of the attenuator grating. It is shown, however, that higher orders of diffraction of polarized light obtained with a coarse grating are not

measurably altered in their degree of polarization, and that the orientation of the plane of polarization of these orders remains identical with that of the incident light. P.K.

## A65-16627

## STIMULATED RAMAN SCATTERING OF LIGHT.

V. A. Zubov, M. M. Sushchinskii, and I. K. Shuvalov.  
(Uspekhi Fizicheskikh Nauk, vol. 83, June 1964, p. 197-222.)  
Soviet Physics - Uspekhi, vol. 7, Nov.-Dec. 1964, p. 419-433.  
24 refs. Translation.

[For abstract see Accession no. A64-23104 19-25]

## A65-16668 \*

## LASER MODE LOCKING BY AN EXTERNAL DOPPLER CELL.

L. Curtis Foster, M. D. Ewy, and C. Burton Crumly (Zenith Radio Research Corp., Menlo Park, Calif.).

Applied Physics Letters, vol. 6, Jan. 1, 1965, p. 6-8.

Demonstration of a method of mode locking by external means. An unmodified standard He-Ne laser at 6328 Å is employed, together with a simple ultrasonic Bragg diffraction cell and a mirror, such that doppler-shifted light is fed back into the laser. The resulting laser output is monitored by an appropriate photodetector at the other end of the laser. It was found that, when the total external path length was approximately equal to the corrected optical length of the laser cavity, optimum locking was obtained, although no critical length adjustments were necessary. In conclusion, several advantages of mode locking by an external doppler cell are cited. A.B.K.

## A65-16670 \*

## GENERATION OF SINGLE-FREQUENCY LIGHT USING THE FM LASER.

G. A. Masey, M. Kenneth Oshman, and Russell Targ (Sylvania Electric Products, Inc., Sylvania Electronic Systems Div., Electronic Defense Laboratories, Mountain View, Calif.).

Applied Physics Letters, vol. 6, Jan. 1, 1965, p. 10, 11.  
Contract No. AF 33(615)-1938.

Description of a technique for producing essentially single-frequency light from the entire output of a high-power multi-mode laser, without suffering the loss of power inherent in conventional approaches involving the suppression of modes. This technique involves the use of a laser in which an intracavity phase perturbation has been utilized to create an array of laser modes having the phases and amplitudes appropriate to the sidebands of an FM signal. The output of the FM laser is then passed through an external phase modulator driven 180° out of phase and with the same peak optical phase deviation as the output of the FM laser. While the output from the FM laser was made up of a large number of optical frequencies, the light leaving the external modulator is, in principle, now a monochromatic signal. A.B.K.

## A65-16671 \*

CW LASER ACTION IN  $\text{N}_2\text{O}$  ( $\text{N}_2\text{-N}_2\text{O}$  SYSTEM).

C. K. N. Patel (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

Applied Physics Letters, vol. 6, Jan. 1, 1965, p. 12, 13. 8 refs.

Description of CW laser oscillation on the P branch rotational transitions of the 001-10<sup>0</sup> vibrational band of  $\text{N}_2\text{O}$  to the ground-state  $\text{N}_2\text{O}$  molecules during collisions of the second kind involving the two molecules. Laser action could not be obtained on these  $\text{N}_2\text{O}$  transitions in a pure  $\text{N}_2\text{O}$  discharge. This points out the effectiveness of the use of transfer of vibrational energy for selective excitation of molecules to certain preferred vibrational levels and subsequently obtaining laser action on the vibrational-rotational transitions of polyatomic molecules. A.B.K.

## A65-16672 \*

## LASER FOCUSING EFFECTS ON SECOND HARMONIC GENERATION IN ADP.

## A65-16673

D. H. McMahon and A. R. Franklin (Sperry Rand Corp., Sperry Rand Research Center, Sudbury, Mass.).

Applied Physics Letters, vol. 6, Jan. 1, 1965, p. 14-16. 7 refs.

Investigation of the variation in second harmonic power produced in ADP by using a focused gas laser beam and measurement of the nonlinear polarization constant. Experiments involving a 0.633- $\mu$  He-Ne gas laser operated so as to produce only TEM<sub>00</sub> modes with vertical electrical fields are described. These experiments are interpreted with the aid of a Huygen's construction technique to calculate, first, the induced nonlinear polarization currents, and, second, to calculate the second harmonic power output by using the spatial and magnitude dependence of the polarization currents. On the basis of an essential agreement between analysis and experimental data, the authors conclude that one can adequately calculate absolute values of the nonlinear polarization constant using focused laser beams. A.B.K.

## A65-16673 \*

A FIELD-INDEPENDENT OPTICALLY PUMPED <sup>87</sup>Rb MASER OSCILLATOR.

P. Davidovits and W. A. Stern (Columbia University, Radiation Laboratory, New York, N.Y.).

Applied Physics Letters, vol. 6, Jan. 1, 1965, p. 20, 21. 5 refs. Contract No. DA-36-039-sc-90789.

Description of a magnetically unshielded optically pumped <sup>87</sup>Rb maser oscillator. The maser will oscillate in the presence of a magnetic field inhomogeneity as large as 10 mG with a total field of 1 G. The excess population in the F = 2 hyperfine level is created by intensity pumping. The <sup>87</sup>Rb and 11 torr of nitrogen buffer gas are contained in a high-Q vacuum-tight microwave cavity, which is designed to operate in the TE<sub>021</sub> mode and has an unloaded Q of approximately 50,000. The cavity is located within a set of Helmholtz coils which provide an orienting field of approximately 1 G along the cavity axis. Self-sustained maser oscillation is observed at a cavity temperature of about 50°C. The oscillator power output is approximately 10<sup>-11</sup> W and is limited by the intensity of the pumping light. The high power output of this maser ensures better short-term stability than that obtainable from all other existing frequency standards. Aside from its potential as a frequency standard, the <sup>87</sup>Rb maser may be used as a very sensitive tool to study frequency shifts caused by optical pumping. A.B.K.

## A65-16680 \*

HYDROGEN MASER AND CESIUM BEAM TUBE FREQUENCY STANDARDS COMPARISON.

H. E. Peters, J. Holloway (Varian Associates, Beverly, Mass.), A. S. Bagley, and L. S. Cutler (Hewlett Packard Co., Palo Alto, Calif.).

Applied Physics Letters, vol. 6, Jan. 15, 1965, p. 34, 35. 11 refs.

Description of direct frequency comparisons between a hydrogen maser and a cesium beam tube frequency standard. The system for frequency comparison is shown in a block diagram. Ten readings of  $N_f$  taken over a period slightly less than 3 hr constitute the data. The rms value of these measurements gave  $N_{f1} = 99,999,992$ , with a standard deviation from the average of 2.5 for each reading. After making certain adjustments to the maser frequency, the average zero-field maser frequency was found to be 1,420,405,751.778  $\pm$  0.016 cps. A.B.K.

## A65-16681 \*

HYDROGEN MASER FREQUENCY COMPARISON WITH SWISS CESIUM ATOMIC BEAM STANDARD.

H. E. Peters (Varian Associates, Beverly, Mass.) and P. Kartaschoff (Laboratoire Suisse de Recherches Horlogères, Neuchâtel, Switzerland).

Applied Physics Letters, vol. 6, Jan. 15, 1965, p. 35, 36. 12 refs.

Description of direct frequency comparisons between a hydrogen maser and a cesium beam tube frequency standard. Two methods of comparing the frequency of the maser to the frequency of the cesium tube were used and are depicted in block diagrams. Four comparison runs were made using method 1, while the final two runs were made with method 2. Each run lasted about 2 hr. After making

adjustments to the maser frequency and the cesium tube frequency, the average zero-field maser frequency was found to be 1,420,405,751.785  $\pm$  0.016 cps. A.B.K.

## A65-16766

LONG-DISTANCE INTERFEROMETRY WITH AN He-Ne LASER.

F. T. Arecchi and A. Sona (Centro Informazioni Studi Esperienze, Laboratori, Milan, Italy).

IN: QUASI-OPTICS; POLYTECHNIC INSTITUTE OF BROOKLYN, MICROWAVE RESEARCH INSTITUTE, SYMPOSIUM, NEW YORK, N.Y., JUNE 8-10, 1964, PROCEEDINGS. [A65-16752 07-23]

Symposium sponsored by the Polytechnic Institute of Brooklyn, the Institute of Electrical and Electronics Engineers, the Optical Society of America, USAF, Navy, and Army.

Edited by Jerome Fox.

Brooklyn, Polytechnic Press, 1964, p. 623-633. 10 refs.

Research supported by the Consiglio Nazionale delle Ricerche.

Discussion of a long distance interferometry experiment where the source is a He-Ne laser working at the 6328-Å transition in single-mode operation. Interference fringes have been observed up to an optical path difference of 120 m (mirror separation 60 m) without a substantial loss of visibility. Laser output is split by a beam-splitter onto a Michelson interferometer through a telescope system which reduces the angular spread. By changing the path difference continuously, in the first experiments the fringe visibility was subjected to a periodical change, going down to zero every time the path difference was an odd multiple of the cavity length. This is due to interference between different axial modes. To avoid this effect both a transverse and an axial selection were made. The isolation of a TEM<sub>00</sub> pattern is accomplished by adjusting two movable diaphragms near the mirror. The selection of a single axial mode was done with an external plane mirror which acts as a second Fabry-Perot. This technique does not reduce the output power, as occurs when a near-threshold operation is used to isolate a single mode. On the contrary, a power increase is observed in the useful mode. An electronic system for measuring and analyzing experimental results is described, and limitations on circuit bandwidth, observation time, and precision are related to fluctuations within the interferometer system and associated circuitry. (Author) F.R.L.

## A65-16798

SOLID STATE MASERS AND THEIR USE IN SATELLITE COMMUNICATION SYSTEMS.

J. C. Walling and F. W. Smith (Mullard, Ltd., Research Laboratories, Redhill, Surrey, England).

Philips Technical Review, vol. 25, no. 11-12, 1963-1964, p. 289-310. 23 refs.

Discussion of the design, performance, and applications of traveling-wave maser (TWM) amplifiers with particular reference to the maser recently developed at Mullard Research Laboratories for use at the Communication Satellite Earth Station of the British General Post Office at Goonhilly Down, Cornwall. Problems of satellite communication are briefly reviewed, with the comment that, in order that the first stage amplifier have the lowest possible noise temperature, it should be a maser. The basic principles of maser operation are discussed in some detail. The theory and design of a traveling-wave maser are examined, and the amplifier designed and built by Mullard Research Laboratories is described. This packaged traveling-wave maser is one of the first such devices to be regularly employed in a systems application, and its operation has proved to be reliable and consistent. Certain operational difficulties, and future developments to further improve the noise performance, are discussed. F.R.L.

## A65-16811 \*

STIMULATED BRILLOUIN SCATTERING IN THE OFF-AXIS RESONATOR.

H. Takuma and D. A. Jennings (National Bureau of Standards, Boulder, Colo.).

Applied Physics Letters, vol. 5, Dec. 15, 1964, p. 239-241. 7 refs.

Study of the Brillouin scattering from an active medium placed in a cavity, the axis of which is rotated from the axis of a ruby laser resonator. At first, the lens, Fabry-Perot interferometer,

and iris were removed from the experimental arrangement in order to investigate the far-field pattern of each component. Benzene and carbon disulfide were chosen as typical and exceptional liquid samples, respectively. When the  $\text{CS}_2$  cell was inserted in the off-axis resonator, the coherent radiation at approximately the same wavelength as the incident laser beam was found to be built up at an exciting power slightly higher than the threshold exciting power of the first stimulated Raman-Stokes line. The angular divergence was measured to be a few milliradians, which was the same as that of the first Stokes line at the same exciting power. On the other hand, when the benzene cell was inserted in the off-axis resonator, no stimulated scattering was observed around the ruby wavelength even under the maximum exciting power ( $50 \text{ mw/cm}^2$ ), at which power the third Stokes line could be observed in the off-axis direction. Thus, stimulated Brillouin radiation built up only in the  $\text{CS}_2$  cell, which is consonant with the exceptionally low threshold exciting power for this type of scattering in  $\text{CS}_2$  found by Garmire and Townes.

W. M. R.

**A65-16863****STUDY OF OPTICAL EFFECTS DUE TO AN INDUCED POLARIZATION THIRD ORDER IN THE ELECTRIC FIELD STRENGTH.**

P. D. Maker and R. W. Terhune (Ford Motor Co., Scientific Laboratory, Dearborn, Mich.).

Physical Review, 2nd Series, vol. 137, Feb. 1, 1965, p. A801-A818, 57 refs.

Presentation of the results of a series of experiments in which a giant pulsed ruby laser is used to study several different nonlinear optical effects arising from an induced optical polarization third order in the electric field strength. The various phenomena studied are special cases of either frequency mixing or intensity-dependent changes in the complex refractive index, including Raman laser action at a focus. A wide range of crystalline and isotropic materials was studied. The theory for these effects is extended to cover resonant interactions. The experimental results are interpreted in terms of simplified models, and quantitative values for the nonlinear polarizability coefficients are given. The rather large experimental uncertainties in these coefficients are discussed.

(Author) F. R. L.

**A65-17043****AN INVESTIGATION OF POTENTIAL LASER CRYSTALS CONTAINING RARE EARTH DOPANTS.**

J. J. Sjöblom (TRG, Inc., Melville, N. Y.).

IN: RARE EARTH RESEARCH II: PROCEEDINGS OF THE THIRD CONFERENCE ON RARE EARTH RESEARCH, CLEARWATER, FLA., APRIL 21-24, 1963. [A65-17039 07-26]

Conference sponsored by the Department of Chemistry, Purdue University.

Edited by K. S. Vorres.

New York, Gordon and Breach Science Publishers, Inc., 1964, p. 65-73, 17 refs.

Contract No. AF 49(638)-673.

Review of the crystal growth and preparation aspects of the rare earth laser program at TRG, Inc. The purpose of this program is to develop solid-state media for lasers based on light absorption and emission by rare earth ions incorporated in the solid-state media. First, a number of rare earth chelates in solution or crystallized from solution were examined. The second system examined was anhydrous lanthanum chloride as the host crystal for anhydrous rare earth chlorides. The third system was based on the scheelite (calcium tungstate) type of crystal as the host. Various other systems have been explored. The scheelite type of crystal doped with neodymium was proved to laser at 1.065 microns. The role of crystal quality in pulsed laser performance is briefly analyzed.

(Author) M. M.

**A65-17052****RARE EARTHS IN OPTICAL MASER MATERIALS.**

K. Nassau (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).

IN: RARE EARTH RESEARCH II: PROCEEDINGS OF THE THIRD CONFERENCE ON RARE EARTH RESEARCH, CLEARWATER, FLA., APRIL 21-24, 1963. [A65-17039 07-26]

Conference sponsored by the Department of Chemistry, Purdue University.

Edited by K. S. Vorres.

New York, Gordon and Breach Science Publishers, Inc., 1964, p. 331-338, 13 refs.

Discussion of chemical interactions between the active ion and the host lattice for selected cases of optical maser crystals. It is stated that, in general, large differences are found in the operation of the same ion in different host lattices. For example,  $\text{Nd}^{3+}$  has the lowest threshold in  $\text{CaWO}_4$ , mediocre thresholds in the other scheelites and in glass, and operates only marginally in the fluorides. Parts of this difference can be explained, by difficulties associated with the growth of some of the scheelites, or by the multiplicity of environments in glasses; others undoubtedly originate in various parameters. Other differences arise from valency, size, or coordination considerations - e.g., the lack of success with divalent ions in the scheelites or with rare earths in the corundum ( $\text{Al}_2\text{O}_3$ ) lattice, which is so well suited for  $\text{Cr}^{3+}$  in ruby. It is noted that, in the absence of general guidelines, it is still necessary to grow individual crystals of each possible active ion in each likely host lattice and to search for optical maser action by direct experimentation. Since the rare-earth concentration in these materials is of the order of 1%, and since quantities are not anticipated to be large, no major use of rare earths can be expected from this field.

M. M.

**A65-17151****THOMSON SCATTERING COMPUTATIONS FOR LABORATORY PLASMAS.**

Edward T. Gerry (Massachusetts Institute of Technology, Dept. of Nuclear Engineering, Research Laboratory of Electronics, Cambridge, Mass.) and Richard M. Patrick (Avco Corp., Avco-Everett Research Laboratory, Everett, Mass.).

Physics of Fluids, vol. 8, Jan. 1965, p. 208-210.

Contracts No. AF 49(638)-1129; No. DA 36-039 AMC 03200(E); NSF Grant No. G 24073; AEC Contract No. AT (30-1)-3221.

Presentation of calculations for the spectrum of the Thomson scattering of a laser beam from an equilibrium hydrogen plasma. The calculations were made in connection with experiments designed to use Thomson scattering as a means for determining plasma properties. The manner in which the character of the scattered spectrum depends upon the ratio of the Debye length to the length in the plasma over which the scattered radiation adds coherently is discussed. The scattered power ratio from an equilibrium hydrogen plasma is plotted against wavelength shift for different number densities and scattering angles at constant temperature.

P. K.

**A65-17207****INFRARED LASER ACTION AND LIFETIMES IN ARGON II.**

F. A. Horrigan, S. H. Koozekanani, and R. A. Paananen (Raytheon Co., Research Div., Waltham, Mass.).

Applied Physics Letters, vol. 6, Feb. 1, 1965, p. 41-43, 5 refs.

Investigation of laser action in argon II between 1 and  $2 \mu$  and in the 6000- to 7000- $\text{\AA}$  range. One of the expected argon II ( $4p \rightarrow 3d$ ) transitions was observed to oscillate weakly. In addition, laser action was found on a neutral argon transition. Both the new laser lines observed in argon showed an optimum pressure of 0.25 torr. This is about one-third to one-half of the optimum pressure required for the visible laser transitions in argon II. In an effort to understand why only one of the  $4p$  to  $3d$  transitions was observed, and that one only weakly, the lifetimes for spontaneous emission were estimated for all the levels of interest of the  $4p$ ,  $4s$ , and  $3d$  groups in argon II. The weakness of the laser action involved is shown to be due mainly to unfavorable branching ratios.

A. B. K.

**A65-17208** **$\text{Yb}^{3+}$ - $\text{Er}^{3+}$  GLASS LASER.**

E. Snitzer and R. Woodcock (American Optical Co., Southbridge, Mass.).

Applied Physics Letters, vol. 6, Feb. 1, 1965, p. 45, 46.

Description of a  $\text{Yb}^{3+}$ - $\text{Er}^{3+}$  glass laser. By energy transfer from  $\text{Yb}^{3+}$  to  $\text{Er}^{3+}$  in a silicate glass,  $\text{Er}^{3+}$  was made to emit

## A65-17210

laser oscillations at  $1.5426 \mu$  as a three-level laser at room temperature. Previously,  $\text{Er}^{3+}$  had been lased in  $\text{CaWO}_4$  at  $1.612 \mu$ , but as a four-level system by cooling to  $77^\circ\text{K}$ . The lifetime for fluorescence of  $\text{Er}^{3+}$  from the  $4I_{13/2}$  level was measured at room temperature on a powdered sample and found to be  $14 \mu\text{sec}$ . The threshold was 700 joules of electrical energy into the flashtube. Work is continuing on this laser with different  $\text{Yb}^{3+}$ - $\text{Er}^{3+}$  ratios and with the use of other ions to sensitize the fluorescence of  $\text{Er}^{3+}$  in order to lower the threshold. A. B. K.

## A65-17210

### LONGITUDINAL INJECTION-PLASMA LASER OF $\text{InSb}$ .

Ivars Melngailis (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).

Applied Physics Letters, vol. 6, Feb. 1, 1965, p. 59, 60. 10 refs.

Description of an  $\text{InSb } n^+pp^+$  structure with a Fabry-Perot cavity designed for coherent emission parallel to the current. To reduce the transverse dimension of the active region, a portion of the  $p^+$  layer is removed by etching. In addition, radial spreading of the plasma is inhibited by the fact that the lifetime of electrons inside the plasma is about  $10^3$  times shorter than outside, thus localizing the injected carriers, by the presence of a second collimating effect resulting from the external magnetic field applied longitudinally to the plasma, and to a minor extent, by the pinch effect of the azimuthal self-magnetic field in the plasma. Coherent emission was obtained near  $10^\circ\text{K}$  with 50-nsec current pulses of 20 amp with a minimum longitudinal magnetic field of 7kG.

A. B. K.

## A65-17219 \*

### THE PHENOMENON OF GENERATION OF A CIRCULAR CYLINDER AND A SPHERE [K IAVLENIU GENERATSII KRUGOVOGO TSILINDRA I SFERY].

A. M. Goncharenko and B. A. Sotskii (Akademiia Nauk Belorusskoi SSR, Institut Fiziki, Minsk, Belorussian SSR).

Akademiia Nauk BSSR, Doklady, vol. 8, Dec. 1964, p. 784-787. 6 refs. In Russian.

Analysis of the problem of stimulated emission of electromagnetic waves from a circular cylinder and a sphere. In particular, it is shown that a radiation, analogous to that of the sphere, occurs on the lateral surface of the cylinder. If this radiation is not used, it would cause additional energy losses in the cylinder. These losses should be absent in a gaseous laser and also in the presence of a dielectric environment on the lateral wall of the cylinder with a refraction index larger than in the active medium.

J. R.

## A65-17319 \*

### OSCILLATION SYNCHRONIZATION IN A SEMICONDUCTOR LASER WITH SEVERAL p-n TRANSITIONS [SINKHORIZATSIIA KOLEBANIY V POLUPROVODNIKOVOM LAZERE S NESKOL'KIMI p-n-PEREKHODAMI].

N. G. Basov, E. M. Belenov, and V. S. Letokhov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Fizika Tverdogo Tela, vol. 7, Jan. 1965, p. 337-339. 5 refs. In Russian.

Theoretical discussion of the synchronization regime for oscillations induced by several p-n transitions, seeking to increase the power and directivity of injection laser emission. The conditions of stability of a synchronization regime are determined. The electromagnetic interconnection of individual transitions by way of field diffractive exchange via the semiconductor is estimated. A block diagram of a laser with several p-n transitions which exchange the field in the outer mirror is plotted. A p-n transition in GaAs is treated as an example of theoretical calculations. V. Z.

## A65-17353 \*

### ON THE OPERATION OF A XENON-KRYPTON LASER.

D. I. Mash, V. F. Papulovskii, and L. P. Chirina.

Optika i Spektroskopiia, vol. 17, Nov. 1964, p. 796-798.)

Optics and Spectroscopy, vol. 17, Nov. 1964, p. 431, 432. 5 refs. Translation.

## A65-17432

### PROBING LASER PARAMETERS WITH SPECIAL PHOTOGRAPHIC TECHNIQUES.

R. W. Wymant, I. T. Basil, and J. H. Cullom (Westinghouse Electric Corp., Defense and Space Center, Advanced Development Surface Div., Baltimore, Md.).

Research/Development, vol. 16, Feb. 1965, p. 27-30.

Presentation of a method of measuring laser beam divergence and energy distribution, utilizing an exceedingly wide-latitude experimental film, and an extremely thin celluloid mirror. New measuring techniques were considered necessary in two specific problems of laser technology: (1) measuring the focusing ability of lenses when they are irradiated with the high intensity beam, and (2) recording an actual far-field pattern of a high-power ruby laser. The film used, presently in its final experimental stages, is made by superposing three layers of panchromatic photographic emulsion, differing widely in sensitivity, to the standard film base. Although the wide latitude of this film permits photographs of objects whose intensity varies over a ratio of  $10^6$ , a method of reducing the intensity of the laser beam without distortion was still necessary, and was accomplished by use of a "pellicle," a clear plastic membrane stretched over a metal frame in a manner similar to a drumhead. An indication of the success of the combination of film and pellicle is derived from some experimental results, and it is concluded that the technique is promising. F. R. L.

## A65-17505 \*

### THEORY OF THREE-LEVEL FREQUENCY CONVERTERS.

Li-Zhi Fang and Tie-Cheng Li.

Acta Physica Sinica, vol. 20, Dec. 1964, p. 1199-1209. 7 refs. In Chinese.

Calculation of curves for the coherent and incoherent output of a three-level ( $E_3 > E_2 > E_1$ ) quantum frequency converter. Optical-to-optical frequency, optical-to-microwave frequency, and microwave-to-microwave frequency conversions are discussed. Two modes of operation of the three-level frequency converter are defined as: (1) one with the pumping frequency  $\sim 1/\hbar(E_2 - E_1)$ , the frequency of the applied signal  $\sim 1/\hbar(E_3 - E_2)$ , and the output frequency  $\sim 1/\hbar(E_3 - E_1)$ , and (2) one with the pumping frequency  $\sim 1/\hbar(E_3 - E_2)$ , the frequency of the applied signal  $\sim 1/\hbar(E_2 - E_1)$ , and the output frequency  $\sim 1/\hbar(E_3 - E_1)$ . The latter is shown to be more efficient than the former for an optical-to-optical frequency conversion. V. Z.

## A65-17514 \*

### OUTPUT STABILITY OF LASERS.

Yu-Ping Ho.

Acta Physica Sinica, vol. 20, Oct. 1964, p. 954-969. 14 refs. In Chinese.

Derivation of semiclassical equations describing the behavior of three-level lasers. The method of nonlinear mechanics is used in treating the electromagnetic oscillations associated with molecule dipole moments. The homogeneous linear molecular width ( $1/T_2$ ), exceeding the resonator's damping width ( $q$ ), is shown to be a precondition of output oscillation amplitude stability (which corresponds to a stable-equilibrium point in phase space) for pumping powers larger than the critical value. Output oscillation instability is linked to coherence effects, and a stable-limit cycle is achieved as this equilibrium point becomes unstable with the increase in  $qT_2$ . The following conclusions are drawn: (1) the theory appears to be true which contends that no limit cycle occurs near a stable equilibrium point and (2) the results outlined above may explain the output oscillation amplitude instability in ruby lasers observed by some authors. It is suggested that the results reported in this paper be minutely checked on gas lasers. V. Z.

## A65-17635

### DEVELOPMENT OF CORNING CODE 0580 LASER GLASS.

T. C. MacAvoy, M. L. Charters, and R. D. Maurer (Corning Glass Works, Corning, N.Y.).

Semiconductor Products and Solid State Technology, vol. 8, Feb. 1965, p. 23-26, 31.

Study of the effect of glass composition,  $\text{Nd}^{3+}$  ion concentration, and impurities (particularly  $\text{Fe}^{2+}$ ), on the spectral properties of Nd-doped glasses. From the glasses studied, one is selected which could be readily melted in optical quality, and special techniques are developed for the analysis and control of critical impurities. Over 100 meters of glass rod five cm in diameter were made, with Mach-Zehnder interferometer patterns indicating a refractive-index homogeneity of  $\pm 10^{-6}$ . This glass homogeneity can only be used in practice if the effect of radial temperature distribution on the optical path is minimized. (Author) P. K.

#### A65-17644 \*

##### A LASER FOG DISDRUMETER.

Bernard A. Silverman (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Bedford, Mass.), Brian J. Thompson, and John H. Ward (Technical Operations, Inc., Burlington, Mass.).

*Journal of Applied Meteorology*, vol. 3, Dec. 1964, p. 792-801. 17 refs.

Description of a laser fog disdrumeter for determining the size distribution of fog droplets down to 4 microns in diameter. A film record of the fog droplets is obtained as they pass relatively undisturbed through the collimated beam of light from a Q-switched pulsed ruby laser. The recording plane is located in the far field of the individual droplets, but not in the far field of the diameter of the whole sample volume. Diffraction patterns associated with the individual droplets are observed and recorded, and measurements of the characteristic dimensions in the patterns allow the droplet diameters to be accurately calculated from well-established diffraction relationships. The short pulse length of the laser, as short as 1.0 microsecond, enables measurements to be made in moderately high winds. The dynamic range and accuracy of the method make it suitable for general laboratory and field drop-size measurements. In addition, the availability of higher repetition-rate lasers makes measurements from aircraft feasible.

(Author) P. K.

#### A65-17648

##### LASER AMPLIFIERS.

Earl L. Steele and Walter C. Davis (North American Aviation, Inc., Autonetics Div., Applied Research Dept., Anaheim, Calif.).

*Journal of Applied Physics*, vol. 36, Feb. 1965, p. 348-351.

Description of the performance of a ruby laser amplifier driven by a Q-switched laser oscillator with a stable output. The system incorporates a newly developed output coupler and a spinning roof-top prism for Q-spoiling. Using a theoretical amplifier model, an expression for gain as a function of energy input is derived, and is fitted to the experimental results. The gain of the 15-cm ruby amplifier is found to saturate at values between 5 and 7, apparently as a result of the complete pumping of the system, rather than due to any limitation of the energy input to the flashlamp pump.

(Author) P. K.

#### A65-17652

##### INTERNAL MODULATION IN MULTIMODE LASER OSCILLATORS.

Amnon Yariv (California Institute of Technology, Pasadena, Calif.). (Annual Conference on Electron Device Research, Cornell University, Ithaca, N.Y., June 1964.)

*Journal of Applied Physics*, vol. 36, Feb. 1965, p. 388-391. 12 refs. Research supported by the Lockheed Independent Research Fund.

Analysis of multimode laser oscillation in the presence of internal resonator modulation. Modulation of the dielectric constant is shown to lead to frequency modulation of the laser light, while modulation of the losses (or gain) leads to amplitude modulation. The results are discussed with particular reference to experiments and proposals involving modulation inside laser resonators. The mathematical formalism used in the analysis is that of normal-mode parametric interactions. (Author) P. K.

#### A65-17654

##### POWER-DEPENDENT FREQUENCY SHIFTS IN RUBY LASERS AT 77°K.

M. Birnbaum and T. L. Stocker (Aerospace Corp., El Segundo, Calif.).

*Journal of Applied Physics*, vol. 36, Feb. 1965, p. 396-402. 17 refs.

Description of power-dependent frequency splitting of the two components of the  $R_1$  ground doublet of ruby lasers operated at 77°K. The frequency differences near threshold measured with Fabry-Perot etalons are in good agreement with the results obtained by microwave methods. As the power level of the laser increases, the frequency difference between the oscillating components decreases. These results are accounted for on the basis of the saturation broadening of overlapping Lorentzian lines. The observed variations in the splitting are in good accord with the theory. The rise in temperature of the ruby rods produces a negligible change in the splitting of the  $R_1$  doublet. The same mechanism which produces the variation of the splitting should broaden the output spectrum of the laser. (Author) P. K.

#### A65-17655

##### TEMPERATURE DEPENDENCE OF THE MULTIMODE BEHAVIOR OF GaAs LASERS.

J. M. Lavine and A. A. Iannini (Raytheon Co., Research Div., Waltham, Mass.).

*Journal of Applied Physics*, vol. 36, Feb. 1965, p. 402-405. 8 refs.

Experimental investigation of the behavior of the higher-order axial modes of Fabry-Perot gas lasers at 4.2° and 77°K. The results are shown to be in good agreement with the theory of Stats and Tang, strongly supporting the model according to which the spatial inhomogeneity of the inverted population in a GaAs laser with a homogeneously broadened spontaneous emission line can lead to multimode oscillation. Since diffusion plays a prominent role in smoothing out these spatial inhomogeneities, the theory calls for, and the experiment verifies, that GaAs lasers must be pumped harder at higher temperatures to produce oscillations in a given number of modes. (Author) P. K.

#### A65-17659

##### REGENERATIVE RUBIDIUM MASER OSCILLATOR.

M. Arditi (International Telephone and Telegraph Corp., ITT Federal Laboratories Div., Nutley, N. J.) and T. R. Carver (Princeton University, Princeton, N. J.).

*Journal of Applied Physics*, vol. 36, Feb. 1965, p. 443-448. 33 refs.

Description of continuous self-sustained oscillations obtained at 6834 Mc with an optically pumped rubidium maser amplifier in a regenerative feedback loop. For an  $87\text{Rb}$  gas cell with pulsed optical pumping, self-sustained oscillations locked to the 0-0 hyperfine transition were obtained by using some additional gain introduced by a low-noise parametric amplifier to overcome insertion and coupling noises. The threshold conditions for self-sustained oscillations in gas cell masers are discussed, and the regenerative method of producing these oscillations is described. The use of the pulsed light for optical pumping allows the oscillation buildup to be studied under various experimental conditions. P. K.

#### A65-17663

##### EFFECTS DUE TO ABSORPTION OF LASER RADIATION.

J. F. Ready (Honeywell, Inc., Research Center, Hopkins, Minn.).

*Journal of Applied Physics*, vol. 36, Feb. 1965, p. 462-468. 20 refs.

Description of methods for calculating the effects produced by high-power laser beams absorbed at opaque surfaces. For calculating heating effects where no phase change is produced, and for studying vaporization by an ordinary millisecond-duration laser pulse, conventional thermodynamic techniques are used. However, for the vaporization produced by the shorter, higher-power pulse from a Q-switched laser, which should proceed differently than the vaporization produced by an ordinary laser, a phenomenological model is used. The results are found to be in agreement with experimental data. P. K.



**A65-17664**

SEARCH FOR A STOKES' SHIFT IN THE  $R_1$  LINES OF RUBY. Peter J. Warter, Jr., Ramon U. Martinelli (Princeton University, Dept. of Electrical Engineering, and Solid State and Materials Program, Princeton, N. J.), and James W. Brault (Princeton University, Palmer Physical Laboratory, Princeton, N. J.). Journal of Applied Physics, vol. 36, Feb. 1965, p. 468-470. 6 refs.

AEC-supported research; NSF Grant No. GP 579.

Experimental study of the possible existence of a Stokes' shift in the  $R_1$  line of ruby. Virtually simultaneous measurements of the emission and absorption profiles of the  $R_1$  line were made for both crystallographic orientations and both polarizations for temperatures from 77° to 153°K. The positions of the peaks in the absorption line are found to match those of the emission line to within 0.002 cm<sup>-1</sup>. Shifts of this size or smaller would have no effect on the operation of a ruby laser. P. K.

**A65-17665**

GaAs INJECTION LASER WITH NOVEL MODE CONTROL AND SWITCHING PROPERTIES.

Marshall I. Nathan, J. C. Marinace, R. F. Rutz, A. E. Michel, and G. J. Lasher (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N. Y.). Journal of Applied Physics, vol. 36, Feb. 1965, p. 473-480. 18 refs.

Experimental investigation of the effects of nonuniform current densities on the properties of GaAs injection lasers. The structure studied is an injection laser with a channel etched on the p side of the junction parallel to the reflecting ends. It is found that the threshold current is higher for nonuniform currents than for uniform currents, and that the mode in which the laser oscillates depends upon the distribution of current. A simple model of the transition and the energy vs density of states for the semiconductor is presented to explain these effects. Bistable operation has been observed with this device. (Author) P. K.

**A65-17684**

FLAWS IN RUBY LASER CRYSTALS.

K. Janowski and H. Conrad (Aerospace Corp., Materials Sciences Laboratory, El Segundo, Calif.). Journal of Applied Physics, vol. 36, Feb. 1965, p. 663, 664.

Description of microscopic flaws appearing as streaks or filaments lying at a large angle to the basal plane in some as-grown ruby laser crystals. These flaws consist of a large number of closely spaced spheroids (voids or precipitate particles) approximately two microns in diameter. It is suggested that they may be agglomerates or vacancies either generated during plastic flow or quenched-in during crystal growth. It is expected that these flaws will cause scattering of the laser beam, resulting in higher threshold values and lower efficiencies. P. K.

**A65-17687**

EFFECTS OF GAMMA IRRADIATION ON THE ENERGY OUTPUT OF RUBY LASER CRYSTALS.

W. R. Davis, A. C. Menius, Jr., M. K. Moss, and C. R. Philbrick (North Carolina University, North Carolina State College, Raleigh, N. C.). Journal of Applied Physics, vol. 36, Feb. 1965, p. 670-672. 12 refs.

Army-supported research.

Study of the effects of <sup>60</sup>Co gamma-irradiation on the performance of laser-quality ruby crystals. The mechanism of energy storage in the additional absorption bands produced by the gamma irradiation is discussed. The results indicate that the irradiation greatly increases laser output. P. K.

**A65-18013**

ACTIVE IMAGE FORMATION IN LASERS.

W. A. Hardy (International Business Machines Corp., Research Div., Yorktown Heights, N. Y.). IBM Journal of Research and Development, vol. 9, Jan. 1965, p. 31-46. 18 refs.

Description of an optical cavity in which the modes are determined as stationary states of the diffraction-limited object/image transformation of classical optics. These modes are selected by the insertion of controls into the optical cavity and lead to field distributions which image these controls. When the cavity is driven by an active medium, laser oscillation can occur, and this is discussed in terms of the coupled-mode equations used by Wagner and Birnbaum in their theory of quantum oscillation in a multimode cavity. Some properties of these modes in the limits of small and large optical aperture are described and illustrated with experiments using the helium-neon gas laser.

(Author) F. R. L.

**A65-18017 #**

MEASUREMENTS OF LASER OUTPUT.

Susumu Takemoto, Wataru Sasaki, and Yoshiyuki Watanabe (Osaka Prefecture University, Dept. of Electronic Engineering, Sakai, Japan).

(Institute of Electrical Engineers of Japan, Annual Meeting, Tokyo, Japan, Apr. 1964.)

Osaka Prefecture University, Bulletin, Series A - Engineering and Natural Sciences, vol. 13, no. 1, 1964, p. 107-112. 7 refs.

Description of the results of the measurement of output of a pulsed ruby laser by an optical bolometer, in which the radiation energy of the laser beam is converted into heat, producing a measurable temperature rise in the energy transducer, which is composed of a bundle of fine insulated copper wire. The maximum energy input of the Xe flashlamp used in the experiment was 400 joule. The net output energy of about  $28 \times 10^{-3}$  joule is obtained when the input of the Xe flashlamp is 400 joule. The output appears to be nearly proportional to the input of the Xe flashlamp in the range below 400 joule. The absorption efficiency of the bolometer was found to be  $\pm 14.2\%$ . F. R. L.

**A65-18037**

STATISTICAL STUDY OF THE PHOTOELECTRONS EMITTED BY A PHOTOCATHODE LIT BY A HEAT SOURCE OR A LASER [ETUDE STATISTIQUE DES PHOTOELECTRONS EMIS PAR UNE PHOTOCATHODE ILLUMINEE PAR UNE SOURCE THERMIQUE OU UN LASER].

Jean Marguin, Raymond Marcy, Georges Hepner, and Georges Pircher (Compagnie Française Thomson-Houston, Centre de Recherches, Service d'Etudes Techniques Avancées, Bagneux, Seine, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 260, no. 5, Feb. 1, 1965, p. 1361-1364. 7 refs. In French.

Presentation of a statistical investigation of the number of photoelectron avalanches counted during a given time T. It is stated that, when T is small compared to the time of correlation of coherent light, deduced from the linewidth, the statistical distribution follows a Poisson law. It is deduced that, in the case considered, the intensity fluctuations are definitely smaller than in the case of natural Gaussian light. M. M.

**A65-18120 #**

INDUSTRIAL POSSIBILITIES OF THE LASER [PROMYSHLENNYE VOZMOZHNOСТИ LAZERA].

V. S. Zuev.

Akademiia Nauk SSSR, Vestnik, vol. 34, Jan. 1965, p. 37-41. In Russian.

Discussion of current and future ruby and neodymium laser applications in industry. The mechanism of laser effect is analyzed in the light of current knowledge. Stepping up of laser efficiency is described as a first-priority goal. The stability of laser substance exposed to a superpower light pulse and the laser applications to superhard material machining and metallurgy are mentioned as other immediate problems to be solved. V. Z.

**A65-18206**

CONJUGATE-CONCENTRIC LASER RESONATOR.

R. V. Pole (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N. Y.). Optical Society of America, Journal, vol. 55, Mar. 1965, p. 254-260. 17 refs.

Description of a laser resonator in which both reflective and refractive surfaces are used as parts of the "resonating circuit." The basic geometry of the resonator, termed conjugate-concentric resonator, is that of a simple imaging system in which the passive lens is replaced by an active one, while the external concentric mirrors occupy an object and an image surface. The eigenvalue problem for this resonator is formulated in both Cartesian and polar coordinates and the corresponding eigenvalues and eigenfunctions are computed numerically. It is then shown that the basic property of this resonator is its high angular degeneracy. This property is said to make it well suited for the application of internal spatial filtering techniques. The practically interesting case of a cosine-shaped spatial filter is considered in some detail. (Author) M. M.

#### A65-18217

##### INTERFEROMETRY WITH ROTATION-INSENSITIVE "CORNER-CUBE" SYSTEMS AND LASERS.

George W. Stroke (Michigan, University, Ann Arbor, Mich.). Optical Society of America, Journal, vol. 55, Mar. 1965, p. 330, 331, 14 refs.

Demonstration that three-mirror 90° corner-cube systems (prisms, mirrors) or equivalent "cat's eye" lens systems can be obtained and made to produce high-contrast laser fringes with a wavefront rotated by 180° back-to-front with respect to a plane-mirror reference wave. The system, which is illustrated in a figure, has the characteristic insensitivity to rotation about the direction of incidence on the corner-cube system as required in

#### A65-18315

##### EIGENMODES OF A SYMMETRIC CYLINDRICAL CONFOCAL LASER RESONATOR AND THEIR PERTURBATION BY OUTPUT-COUPLING APERTURES.

D. E. McCumber (Bell Telephone Laboratories, Inc., Murray Hill, N. J.). Bell System Technical Journal, vol. 44, Feb. 1965, p. 333-363, 22 refs.

Calculation of the diffraction losses and the field distributions at the reflectors of the low-loss modes of a symmetric confocal resonator for Fresnel numbers  $0.6 \leq N_m \leq 2.0$ , using a numerical technique which is different from the iteration method of Fox and Li and which is said to be more suitable for the analysis of high-order modes. The modifications which result when the two end reflectors are perturbed by circular output-coupling apertures centered on the cavity axis were also computed. It is stated that, for a range of small but useful aperture Fresnel numbers  $N_0$ , the aperture diffraction losses can be estimated by the first-order perturbation theory from the finite- $N_m$  results appropriate to  $N_0 = 0$ . It is noted that such estimates fail for those larger Fresnel numbers  $N_0$  for which the mode-intensity patterns are significantly distorted at the reflectors by the finite-coupling apertures. (Author) M. M.

#### A65-18320 \*

##### MEASUREMENT OF SHORT-TERM FREQUENCY INSTABILITY AND FREQUENCY SPECTRA OF HIGHLY STABLE OSCILLATORS.

Yoshiyuki Yasuda and Kazuyoshi Yoshimura. Radio Research Laboratories, Journal, vol. 11, Sept. 1964, p. 313-330, 5 refs.

Measurement of the short-term frequency instability of highly stable quartz oscillators on 100 kc, 2.5 Mc, and 5 Mc for averaging times of 0.001, 0.01, 0.1, 1, and 10 sec, and of the frequency spectra, by the use of the double-beam ammonia maser as the reference standard. It is stated that the measurement of the instability was much influenced by hum modulation - phase modulation by power frequency (50 cps) or its multiples - and by phase variation in the frequency multiplier. The former affects the instability for about 0.001 to 0.01 sec of measurement, and the latter for a few tenths of a second to a few seconds. The effect of the multiplier and hum modulation is much larger on the 100-kc oscillator than on the 2.5-Mc and 5-Mc oscillators. It is noted that, for the averaging time of about ten seconds, the instability of these oscillators was less than a few parts in  $10^{11}$  with negligibly small effect of the measuring devices. (Author) M. M.

#### A65-18375 \*

##### PLASMA LASER AS THE ENGINE OF A PHOTON ROCKET [PLAZ-MENNYI LAZER KAK DVIGATEL' FOTONNOI RAKETY].

L. I. Gudzenko and L. A. Shelepin. Kosmicheskie Issledovaniia, vol. 3, Jan.-Feb. 1965, p. 167, 168. In Russian.

Brief discussion of a photon rocket powered by a relatively small-power laser whose emission is increased by an optical quantum amplifier efficient enough to produce a unidirectional photon flux, which in turn generates thrust. Difficulties encountered in the materialization of photon rockets are analyzed. V. Z.

#### A65-18434 \*

##### EXCITATION OF COMPLEMENTARY OFF-AXIS BEAMS OF STIMULATED RADIATION [VOZBUZHDENIE DOPOLNITEL'NYKH VNEOSEVYKH PUCHKOV STIMULIROVANNOGO IZLUCHENIYA]. M. P. Vaniukov, V. I. Isaenko, L. A. Luizova, and O. A. Shorokhov (Gosudarstvennyi Opticheskii Institut, Leningrad, USSR). Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Jan. 1965, p. 3-6, 5 refs. In Russian.

Investigation of the excitation of off-axis stimulated-radiation beams by introducing an angle of incidence between the generating sample and the interferometer axis. It is shown that the radiation coincides in time with that propagated in the axial direction, and that the propagation angles of the radiation correspond to the equal-inclination fringes of a Fabry-Perot interferometer, formed by resonator mirrors. V. P.

#### A65-18455 \*

##### LIGHT AMPLIFICATION BY FOUR-LEVEL QUANTUM SYSTEMS [USILENIE SVETA CHETYREKHUROVNEVYMI KVANTOVYMI SISTEMAMI].

Iu. A. Anan'ev, A. A. Mak, and B. M. Sedov (Gosudarstvennyi Opticheskii Institut, Leningrad, USSR). Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Jan. 1965, p. 7-12, 5 refs. In Russian.

Discussion of the steady-state and transient modes of light amplification during the passage, through a four-level active medium, of monochromatic radiation at a wavelength corresponding to the maximum negative absorption coefficient of the medium. The method of probabilities is used to study the light amplification in  $\text{CaF}_2 : \text{Sm}^{2+}$ . The decrease in lifetime of the excited state is calculated for large values of population inversion. Two types of losses in an active medium are examined. V. P.

#### A65-18460 \*

##### EXCITATION OF MODES AND THE OSCILLATION KINETICS IN A RUBY LASER WITH A CONCENTRIC CAVITY RESONATOR [VOZBUZHDENIE MOD I KINETIKA GENERATSII V RUBINOVOM GENERATORE S KONTSENTRICHESKIM REZONATOROM].

V. V. Korobkin, A. M. Leontovich, and M. N. Smirnova (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Jan. 1965, p. 78-86, 17 refs. In Russian.

Investigation of the mode excitation and amplification kinetics of a ruby laser with external concentric mirrors by means of a high-speed high-resolution streak camera. The emission spectrum of the laser is investigated by means of a Fabry-Perot interferometer. A study of the distribution of laser emission at the mirrors and in the center of the resonator during regular operation in which the oscillations are damped to a certain level, revealed the excitation of a large number of high-order transverse modes, while for irregular operating conditions (depending on the position of the mirrors and the crystal, and on pumping), the number of the excited modes is small. The oscillation-frequency bandwidth in the regular mode is found to equal 0.5 to 0.1  $\text{cm}^{-1}$ , and 0.1  $\text{cm}^{-1}$  in the irregular mode. The mean frequency of the oscillations tends to decrease with operation time. Both smooth variations in the oscillation frequency and abrupt frequency changes of the order of 0.1 to 0.4  $\text{cm}^{-1}$  are observed. An explanation of these results on the basis of energy-balance considerations is proposed. V. P.

**A65-18461 \***

CHANGE OF A RUBY LASER RESONATOR WHEN HEATED BY PUMPING LIGHT [IZMENENIE REZONATORA RUBINOVOGO GENERATORA PRI NAGREVANII SVETOM NAKACHKI].

A. P. Veduta, A. M. Leontovich, and V. N. Smorchkov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, Jan. 1965, p. 87-93. 13 refs. In Russian.

Interferometric investigation of the change in the equally broad bands of several ruby lasers with plane-parallel ends during pumping. A gaseous laser operating at  $\lambda = 6328 \text{ \AA}$  is used as a light source for the interferometer. It is found that nonuniform heating of the crystal by the pumping light leads to a change in the resonator geometry; the cavity resonator becomes spherical, which is advantageous for amplification. Nonuniform heating can be achieved by focusing the pumping light by the lateral cylindrical surfaces of the crystal and by the excitation of internal modes. The heating of the crystal is found to be proportional to the chromium concentration in the crystal. For a pumping energy of 5 kilojoule and a chromium content of 0.018%, the crystal was heated to  $4.8^\circ\text{C}$ , which exceeds the theoretical value by a factor of 1.5. The energy absorbed by the crystal during pumping, and the efficiency of the pumping lamp are calculated. Interference patterns of the rubies obtained at different times after the initiation of pumping and for pumping energies from 5 to 15 kilojoule are presented. V. P.

**A65-18462 \***

CHARACTERISTICS OF A RUBY LASER OPERATING IN THE PULSED Q-FACTOR MODE [KHARAKTERISTIKI OPTICHESKOGO KVANTOVOGO GENERATORA NA RUBINE, RABOTAIUSHCHEGO V REZHIME IMPUL'SNOI DOBROTNOSTI].

T. V. Gvaladze, I. K. Krasniuk, P. P. Pashinin, A. V. Prokhindeev, and A. M. Prokhorov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, Jan. 1965, p. 106-110. 10 refs. In Russian.

Investigation of a laser with modulated Q-factor, using a rotating total-reflection prism. The device produces a power of  $\sim 50 \text{ Mw}$  at a pulse duration of 40 to 50 nsec. Analytical expressions for calculating the maximum values of the laser peak power and output energy are derived. The negative absorption coefficient is determined for a 115-mm-long and 12-mm-diam. crystal with coated ends. It is shown that, to obtain maximum amplification pulses, high-transmittance base layers acting as a mode selector should be used. The emission spectrum of the laser is studied by means of a Fabry-Perot interferometer. P. V.

**A65-18555 \***

A PLANE-PARALLEL GLASS PLATE IN A LASER RESONATOR [PLOGOPARALLEL'NAIA STEKLIANNAIA PLASTINKA V REZONATORE OPTICHESKOGO KVANTOVOGO GENERATORA].

Iu. D. Kolomnikov, Iu. V. Troitskii, and V. P. Chebotaev. *Radiotekhnika i Elektronika*, vol. 10, Feb. 1965, p. 370, 371. In Russian.

Experimental investigation of the relationship between the output of a gaseous laser and the angle of beam incident upon a plane-parallel glass plate introduced into the laser resonator. It is found that the laser operates not only when the plate is perpendicular to the axis of the system, but also when it is deflected from this position at small angles at which reflection losses are reduced due to the interference of beams reflected from two surfaces of the plate. It is noted that plane-parallel glass plates can be used in a laser resonator as optical windows of controlled load for tuning out competing emission at another wavelength, for measuring plate thickness, etc. J. R.

**A65-18556 \***

A MODE OF OPERATION OF A He-Ne LASER [OB ODNOM REZHIME RABOTY OPTICHESKOGO KVANTOVOGO GENERATORA NA SMESI GELII-NEON].

V. P. Chebotaev.

*Radiotekhnika i Elektronika*, vol. 10, Feb. 1965, p. 372, 373. In Russian.

Study of the operation of a He-Ne laser with a discharge in a hollow-cathode tube. In order to determine optimum conditions for the laser operation, a discharge in a hollow-cathode tube with a He-Ne mixture is spectroscopically investigated. It is found that emission regimes on the lines of  $6328 \text{ \AA}$  and  $11,523 \text{ \AA}$  are in good agreement with regimes of the largest increase in the intensity of the  $6328\text{-}\text{\AA}$  and  $11,523\text{-}\text{\AA}$  lines during the discharge in the hollow-cathode tube due to inelastic collisions of neon atoms with metastable helium atoms. J. R.

**A65-18557 \***

THE EFFECT OF HYDROGEN AND OXYGEN ON THE OPERATION OF A NEON LASER [O VLIANII VODORODA I KISLORODA NA RABOTU OPTICHESKOGO KVANTOVOGO GENERATORA NA NEONE].

V. P. Chebotaev.

*Radiotekhnika i Elektronika*, vol. 10, Feb. 1965, p. 374-376. 9 refs. In Russian.

Experimental investigation of the operation of a laser on neon-hydrogen and neon-oxygen mixtures in which metastable neon atoms are effectively annihilated by hydrogen and oxygen molecules, thus leading to the inverse population of the  $2s - 2p$  levels of neon in the case of pure electron excitation. Experiments are carried out in the discharge of a hollow-cathode tube. As a result, laser emission is obtained on the lines of  $11,523 \text{ \AA}$  and  $11,767 \text{ \AA}$  in the neon-oxygen mixture. The annihilation of metastable neon atoms by oxygen is associated with the dissociation of oxygen molecules on excited atoms. This phenomenon can be used to obtain inverse populations between levels of oxygen atoms. For small current densities, the output of a He-Ne laser exceeds that of the Ne-H laser. J. R.

**A65-18558 \***

CONDITIONS FOR THE OPERATION OF A He-Xe LASER IN THE CENTRAL INFRARED REGION OF THE SPECTRUM [USLOVIA RABOTY OPTICHESKOGO KVANTOVOGO GENERATORA NA SMESI GELII-KSENON V SREDNEI INFRAKRASNOI OBLASTI SPEKTRA].

A. A. Kuznetsov and D. I. Mash (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Radiotekhnika i Elektronika*, vol. 10, Feb. 1965, p. 376, 377. In Russian.

Experimental study of the operation of a He-Xe laser with inner mirrors in the infrared region of the spectrum. One of the mirrors was in the form of a spherical germanium plate, and the other spherical mirror was fully silver-coated. As a result, the relationship between the output emission and the general pressure of the gas mixture is established. The strongest emission was obtained on the  $3\ 5070\text{-}\mu$  and  $5\ 5738\text{-}\mu$  lines. J. R.

**A65-18795 \***

GEOMETRY OF THE RADIATION FIELD FOR A LASER INTERFEROMETER.

M. J. Offerhaus.

*Philips Research Reports*, vol. 19, Dec. 1964, p. 520-523. 5 refs.

Description of simple planimetric constructions that yield the main geometrical properties common to all modes of oscillation in a laser interferometer with spherical mirrors of unequal curvatures. Given the radii of curvature of the two mirrors and the channel length, the following characteristics are determined: the position of the central plane of symmetry, the spot size for each wavefront at a varying distance from the central plane, and the frequency spacing between successive groups of transverse modes. (Author) W. M. R.

**A65-18849**

FAR-INFRARED MASERS.

C. G. B. Garrett (Bell Telephone Laboratories, Inc., Optical Electronics Research Dept., Murray Hill, N.J.).

*International Science and Technology*, Mar. 1965, p. 39-44.

Review of efforts to close the gap between the longest-wavelength maser (HCN, 337  $\mu$ , pulsed) and the shortest commercial microwave oscillator (Carcinotron, 590  $\mu$ , CW). In 1923, Nichols and Tear used a spark gap to generate detectable amounts of power at a wavelength of 220  $\mu$ , while Rubens and his collaborators, working from the other end, pushed the long-wavelength limit for infrared experiments to about 440  $\mu$ , using the mercury lamp and the Welsbach mantle as sources of radiation. However, only in the last 3 yr have infrared oscillators (Xe, Ne, H<sub>2</sub>O, and HCN gas lasers) been developed that can produce signals of well-defined frequency and power limited only by the ingenuity of the designer. The general principles of these devices are described. W. M. R.

#### A65-18872

##### pn JUNCTION ELECTROLUMINESCENCE AND DIODE LASERS.

Henry T. Minden (Sperry Rand Corp., Sperry Rand Research Center, Solid State Sciences Dept., Sudbury, Mass.).  
*Sperry Engineering Review*, vol. 17, Winter 1964, p. 8-15. 41 refs.

Discussion of the theory and applications of junction diode lasers. When an electric current passes through certain solids, resonant optical radiation (known as electroluminescence) is emitted in a narrow band. Among the materials known to emit such radiation are: PbSe, PbTe, InSb, InAs, InP, InAsP, GaAs, and GaInAs; each material radiates at its own characteristic wavelength. The fabrication of a typical GaAs electroluminescent diode is described, and expressions are given for the gain, power efficiency, quantum efficiency, conditions for resonant feedback, and mode spacing for the device. Other topics discussed include spatial coherence and modulation (including Q switching and quenching). The discussion of quenching, amplification, and bistable devices suggests the possibility of using these devices in computer applications. Logical processes would occur at speeds equal to the laser-action modulation speeds: about 1 Gc. Optical coupling could be achieved by integrated circuit techniques. D. H.

#### A65-18873

##### Nd:CaWO<sub>4</sub> LASER OSCILLATORS AND AMPLIFIERS.

Leo M. Fatur and Charles B. Zarowin (Sperry Rand Corp., Electro-Optics Engineering Dept., New York, N.Y.).  
*Sperry Engineering Review*, vol. 17, Winter 1964, p. 21-25.

Review of what is known about the use of neodymium-doped calcium tungstate as a room-temperature amplifier and CW-laser oscillator. These doped crystals exhibit optical gain under appropriate conditions at the near IR wavelength of 1.06  $\mu$ , and - less importantly - at 0.9 and 1.3  $\mu$ . Pumping is accomplished with available mercury-arc pump lamps. High quality Nd:CaWO<sub>4</sub> crystals have been grown, and this work and work with a high-power laser are described. D. H.

#### A65-18887

##### SATURATION EFFECTS IN SOLID-STATE LASER AMPLIFIERS.

K. N. Seeber (Raytheon Co., Space and Information Systems Div., Bedford, Mass.).  
*IEEE Transactions on Electron Devices*, vol. ED-12, Feb. 1965, p. 63-66. 9 refs.

Presentation of a phenomenological treatment of saturation effects in solid-state laser amplifiers. Numerical calculations are carried out for neodymium-doped CaWO<sub>4</sub> and glass amplifiers. It is concluded that even in the absence of hole burning effects, saturation limits the gain of the laser amplifier. If hole burning occurs, it will adversely affect the gain of single-mode, frequency-stabilized input signals of great spectral purity. F. R. L.

#### A65-19046 \*

##### UTILIZATION OF THE LASER FOR LONG RANGE MEASUREMENT OF TRAJECTORIES [UTILISATION DU LASER POUR LA TRAJECTOMETRIE A GRANDE PORTEE].

Claude Vêret (ONERA, Division Optique, Châtillon-sous-Bagneux, Seine, France).  
(Réunion sur les Equipements des Champs de Tir, CERES, Sept. 22, 1964, Paper.)  
ONERA, TP no. 166, 1964. 17 p. In French.

Presentation of an experimental verification of the limiting range of a laser telemetric system associated with a reflected laser impulse from the image, taking atmospheric perturbations into account. It is considered that such a method of telemetry could give, theoretically, an accuracy of angular coordinates of better than one second. F. R. L.

#### A65-19066 \*

LASER PHOTOMETRY BY A PHOTOELECTRIC CELL [PHOTOMETRIE DU LASER PAR CELLULE PHOTOELECTRIQUE].  
Michel Philbert (ONERA, Châtillon-sous-Bagneux, Seine, France).  
(Symposium International sur la Physique du Laser et ses Applications, Bern, Switzerland, Oct. 12-14, 1964, Paper.)  
ONERA, TP no. 182, 1964. 13 p. In French.

Discussion of the principal steps taken in the course of work undertaken by the optical division of ONERA for the purpose of working out and calibrating a photoelectric cell device intended to make absolute measurements of the power of various types of laser apparatus. Methods of calibration are stressed. These consist of calibration of the photoelectric receiver, and development and calibration of laser emission flux attenuators in connection with a known and compatible receiver sensitivity. F. R. L.

#### A65-19074

##### VARIATION WITH TIME IN THE INTENSITY AND ENERGY OF THE STIMULATED RADIATION OF A RUBY LASER WITH SPHERICAL MIRRORS.

A. K. Sokolov and T. N. Zubarev.  
(*Fizika Tverdogo Tela*, vol. 6, Sept. 1964, p. 2590-2598.)  
*Soviet Physics - Solid State*, vol. 6, Mar. 1965, p. 2065-2070.  
Translation.

#### A65-19176

##### GENERATION OF OPTICAL HARMONICS.

H. J. Okoomian (Radio Corporation of America, Defense Electronic Products, Aerospace Systems Div., Burlington, Mass.).  
IN: ELECTRO OPTICS.  
Camden, N. J., Radio Corporation of America, 1964, p. 28-31.  
8 refs.

A theoretical and experimental consideration of new techniques in the field of optical harmonics. Techniques for the production of second harmonic radiation have been developed sufficiently to demonstrate the utility of this approach for frequency translation of high-power coherent sources important in applications such as rangefinders, active tracking systems, and communications. The utility of the technique in special applications is illustrated by the example of a wholly self-contained submersible transmitter using second harmonic radiation (5300 Å) with a Q-switched neodymium-glass laser for the fundamental radiation (10,600 Å), constructed and tested under water at the David Taylor Model Test Basin, Washington, D. C., with the particular advantage that transmission in sea water is maximal for green radiation. D. M.

#### A65-19184

##### FABRICATION AND TEST OF A CW LASER OF CaF<sub>2</sub>:Dy<sup>2+</sup>.

B. R. Clay and T. A. Haddad (Radio Corporation of America, Defense Electronic Products, Aerospace Systems Div., Burlington, Mass.).  
IN: ELECTRO OPTICS.  
Camden, N. J., Radio Corporation of America, 1964, p. 62, 63.

A note describing design, fabrication, and testing of a laser using new material. An apparatus was constructed for obtaining continuous laser action from divalent Dy in CaF<sub>2</sub> excited by a tungsten lamp. The pump optics consisted of an elliptical cylinder substrate with an evaporated coating in which liquid N<sub>2</sub> was circulated and the exhaust reflexed into the pump interior for further cooling. A continuous output was achieved with an input of approximately 500 watts. The problems peculiar to lasers of this type are: (1) need for operation at or below b. p. of N<sub>2</sub> (77°K at 1 atm); and (2) avoidance of coolant boiling in either pump or output paths to avoid attenuation and scattering caused by bubbles. These problems were solved by special mounting. In testing, continuous laser

## A65-19227

action was observed with an input of 72 volts to the lamp when the coolant was liquid  $N_2$ . Lower thresholds were observed with lower-temperature coolants. Unique characteristics of the new material are: (1) extremely narrow linewidth (known to be less than  $0.01 \text{ \AA}$ ); (2) capability of going CW with moderate pumping; (3) quite broad pump bands, extending more or less throughout the visible spectrum; and (4) possibility of changing output radiation amplitude and frequency by the application of relatively weak axial magnetic fields (Zeeman splitting). D.M.

## A65-19227

### MICROWAVE PHOTODIODES EXHIBITING MICROPLASMA-FREE CARRIER MULTIPLICATION.

L. K. Anderson, P. G. McMullin, L. A. D'Asaro, and A. Goetzberger (Bell Telephone Laboratories, Inc., Murray Hill, N.J.). Applied Physics Letters, vol. 6, Feb. 15, 1965, p. 62-64. 6 refs. Description of microwave amplification achieved in a silicon diode exhibiting microplasma-free avalanche multiplication. Measurements on a guard-ring photodiode were made at  $6328 \text{ \AA}$  with a gas laser modulated at 1.5, 3, 6, and 10 Gc. Sufficient noise-free current gain was achieved to obtain output SNR's limited only by shot noise in the photocurrent. While the electroluminescence from the avalanche region of the diode showed mottled emission, no bright microplasmas were present. P.K.

## A65-19234

### CONTINUOUS OPERATION OF A RUBY LASER AT ROOM TEMPERATURE.

V. Evtuhov and J. K. Neeland (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.). Applied Physics Letters, vol. 6, Feb. 15, 1965, p. 75, 76. 6 refs. Contract No. AF 33(657)-11650.

Description of continuous laser action obtained in water-cooled ( $\sim 10^\circ\text{C}$ ) ruby rods. The rods were 2 mm in diam., 2.54 cm long, and had ends with slightly positive curvature to ensure operation with stable modes of low diffraction loss. Both multilayer-dielectric and silver reflectors were used on the ruby faces. The pumping cavity was a stainless steel elliptical cylinder. A mercury arc lamp was used for continuous action, and a xenon lamp for pulsed operation. The laser operating characteristics are described. P.K.

## A65-19235

### NONLINEAR OPTICAL INTERACTIONS IN $\text{LiNbO}_3$ WITHOUT DOUBLE REFRACTION.

Robert C. Miller, G. D. Boyd, and A. Savage (Bell Telephone Laboratories, Inc., Murray Hill, N.J.). Applied Physics Letters, vol. 6, Feb. 15, 1965, p. 77-79. 14 refs.

Description of velocity-matched second harmonic generation (SHG) and mixing obtained in piezoelectric  $\text{LiNbO}_3$  crystals. By matching the phase velocity of the second-order polarization wave with that of the radiation it produces, double refraction is eliminated and it becomes possible to make optimum use of the nonlinear properties of the crystals. An He-Ne gas laser with four lines from 1.153 to 1.198 microns is used to study the SHG and mixing for the crystals. P.K.

## A65-19342

### LASER DIGITAL DEVICES.

Walter F. Kosonocky. IEEE Spectrum, vol. 2, Mar. 1965, p. 183-195. 29 refs.

Discussion of the theory of operation of laser digital devices which may be used for general-purpose logic circuits in much the same way that transistors are now used, except that all of the processing is done with optical signals rather than electrical signals. The two basic nonlinear processes involved are (1) the quenching of gain in a laser and (2) saturation of optical absorption. Tests of saturation of absorption on a  $1/4$ -in. ruby cube and on vanadyl phthalocyanine (VOPc) in toluene are described. Equipment used in the dual-beam absorption tests is shown in a schematic drawing. Circuits investigated included: the laser inverter circuit and bistable and monostable circuits. Semiconductor current-injection

lasers (probably operating at liquid nitrogen temperatures) are considered most attractive for digital devices because of their small size, high pumping efficiency, and high speed of operation. D.H.

## A65-19544

### MEASUREMENT OF AMPLITUDE NOISE IN OPTICAL CAVITY MASERS.

Charles Freed (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.) and Hermann A. Haus (Massachusetts Institute of Technology, Dept. of Electrical Engineering and Research Laboratory of Electronics, Cambridge, Mass.). Applied Physics Letters, vol. 6, Mar. 1, 1965, p. 85-87. 6 refs. Contract No. DA-36-039-AMC-03200(E).

Description of measurements on the amplitude noise of a cavity-type gaseous optical maser oscillator operating at  $6328 \text{ \AA}$  above and below threshold. The results above threshold are compared with the theory of noise in Van der Pol oscillators, which is the proper one to use for the maser oscillator, and the measurements below threshold with the linear theory of maser amplifiers. Because of the quantitative agreement, it is concluded that the noise is due to spontaneous emission. The composite experimental results are shown. M.M.

## A65-19546

### LASER EMISSION FROM n-TYPE GaAs EXCITED BY FAST ELECTRONS.

D. A. Cusano and J. D. Kingsley (General Electric Co., Research Laboratory, Schenectady, N.Y.). Applied Physics Letters, vol. 6, Mar. 1, 1965, p. 91-93. 7 refs.

Description of the excitation of coherent emission with fast electron beams in n-type GaAs crystals at 77 and  $20^\circ\text{K}$ . The donor concentrations in the samples studied were  $2.3 \times 10^{17}$ ,  $1.1 \times 10^{18}$ , and  $4.9 \times 10^{18} \text{ cm}^{-3}$ . The electrons were accelerated to energies from 16 to 30 keV, and the threshold current densities ranged from  $0.3$  to  $10 \text{ amp/cm}^2$ . The most heavily doped samples emitted stimulated radiation at photon energies up to  $1.54 \text{ eV}$ , well above the  $77^\circ\text{K}$  band gap of  $1.51 \text{ eV}$ . It is stated that evidence of the spatial coherence of the emitted radiation has been obtained from the narrowing of its angular distribution. It is noted that, in all the samples, the coherent emission occurs predominantly at lower photon energies than the incoherent maximum. The spatial coherence of the emission was observed with an infrared image converter placed a few inches from the sample. It is pointed out that none of the very lightly doped samples has shown emission energies much greater than the band gap which could be clearly identified as band-to-band recombination. M.M.

## A65-19569 #

### INTERFERENCE METHOD OF MEASURING THE HOMOGENEITY OF RUBY RESONATORS FOR LASERS [INTERFERENČNÍ MĚŘENÍ HOMOGENITY RUBÍNOVÝCH REZONÁTORŮ PRO LASER].

V. Boček (Československá Akademie Věd, Ústav Přístrojové Techniky, Brno, Czechoslovakia) and V. Kment (Spolek pro Chemickou a Hutní Výrobu, Ústí nad Labem, Czechoslovakia). Jemná Mechanika a Optika, vol. 9, Jan. 1965, p. 5-6. 11 refs. In Czech.

Description of interferometric determinations of the homogeneity of ruby-laser rods. An Askania IG140 interferometer in a Michelson-interferometer configuration was employed in making the measurements; a Fabry-Perot system is also described. Radiation wavelengths used were the  $6438\text{-}\text{\AA}$  line of cadmium and the  $6328\text{-}\text{\AA}$  line from a He-Ne laser. D.H.

## A65-19596

### SOME PARAMETERS OF A LASER-TYPE BEYOND-THE-HORIZON COMMUNICATION LINK.

M. King (Columbia University, Dept. of Electrical Engineering, New York, N.Y.) and S. Kainer (International Telephone and Telegraph Corp., ITT Federal Laboratories Div., Nutley, N.J.). IEEE, Proceedings, vol. 53, Feb. 1965, p. 137-141. 11 refs.

Discussion of beyond-the-horizon propagation of laser beams by means of scattering from clouds and hazes as applied to communication systems. Expressions for the information capacity of such

a communication link are derived from consideration of the scattering properties of such clouds and hazes and from other system parameters. It is noted that a more detailed investigation of the properties and potentialities of such a communication system seems warranted. (Author) M.M.

#### A65-19598

##### CHARACTERISTICS OF A RAMAN LASER EXCITED BY AN ORDINARY RUBY LASER.

H. Takuma (Tokyo, University, Dept. of Applied Physics, Tokyo, Japan) and D. A. Jennings (National Bureau of Standards, Boulder, Colo.).

IEEE, Proceedings, vol. 53, Feb. 1965, p. 146-149. 9 refs.

Experimental investigation of the stimulated Raman effect of benzene using an ordinary (nongiant) ruby laser. The buildup of oscillation at the  $\nu_2$ ,  $2\nu_2$ ,  $3\nu_2$ , and  $4\nu_2$  Stokes lines and also at the first  $\nu_1$  Stokes line has been observed. The threshold exciting power for laser action in the  $\nu_2$  Stokes line has been measured to be 9.5 kw. A rate equation for the Raman laser has been given, and the total scattering cross section for the  $\nu_2$  Raman line of benzene has been determined as  $\sigma = 0.46 \times 10^{-28} \text{ cm}^2$ . It is stated that the estimation based on the results of this investigation indicates that it is possible to construct a Raman laser of benzene using an Ar gas laser. (Author) M.M.

#### A65-19601

##### A PROPOSED METHOD FOR REDUCING THE LOCKING FREQUENCY OF A RING LASER.

R. C. Smith and L. S. Watkins (Southampton, University, Dept. of Electronics, Southampton, England).

IEEE, Proceedings, vol. 53, Feb. 1965, p. 161. 5 refs.

Research supported by the British Aircraft Corp. (Operating), Ltd., and Department of Scientific and Industrial Research.

Description of a method for reducing the locking frequency comparable to the width of a ring laser. Instead of the two beams propagating around the ring, it is proposed to make them orthogonal. Any backscatter will then be of the wrong polarization and should therefore have a much smaller pulling effect on the other beam. The assumption which is implicit is that the polarization of the light scattered backwards - i.e., at  $180^\circ$ , remains unchanged. It is stated that the orthogonal condition can be obtained by the use of an external feedback loop containing a Faraday isolator, which is shown. With orthogonal polarizations, the optical length of the cavity can be different for the two beams because of birefringence in the cavity media, even though they still travel around the same path. It is stated that laser tubes with Brewster-angled windows would not be suitable because of their strong polarization dependence. It is noted that, besides making an improved laser gyroscope, the modified ring laser described also forms an extremely sensitive polarimeter for measuring birefringence. M.M.

#### A65-19602

##### A CIRCULAR RING LASER.

I. Itzkan (Sperry Rand Corp., Sperry Gyroscope Co., Electro-Optics Group, Great Neck, N.Y.).

IEEE, Proceedings, vol. 53, Feb. 1965, p. 164. 6 refs.

Consideration of what would be required to generate a truly circular mode of oscillation in a gas laser system. The case examined is that of a ray of light which is repeatedly reflected from the inside surface of a dielectric circular cylinder such that its path closes upon itself and is an inscribed regular polygon with  $m$  sides, as shown by a figure. It is stated that an actual operating device would require a partition for directing the discharge and a method of coupling out the energy in the two contrarotating modes. An optical flat oriented at  $45^\circ$  might serve both purposes. It is possible that for some special applications the simplicity of the circular ring would outweigh some obvious disadvantages. M.M.

#### A65-19603

##### LASER PHASE-LOCKED LOOP.

L. H. Enloe and J. L. Rodda (Bell Telephone Laboratories, Inc., Holmdel, N.J.).

IEEE, Proceedings, vol. 53, Feb. 1965, p. 165, 166.

Description of an experiment in which two lasers are made to oscillate at exactly the same frequency (approximately  $5 \times 10^{14} \text{ cps}$ ) with a phase difference of less than one-third of a degree. The lasers are coupled by means of a low-frequency circuit, as opposed to coupling by purely optical means. The experimental setup is entirely analogous to the phase-locked loops used at radio frequencies. It is stated that the phase-locked loop is an important tool at radio frequencies, particularly in synchronous communication techniques. At optical frequencies, it should find an even wider range of application. It is noted that, in homodyne detection, for instance, a phase-locked loop is required to lock the phase of the optical local oscillator signal to that of the received optical carrier. Preliminary results obtained on such an optical phase-locked loop are described. M.M.

#### A65-19618

##### A RUBY LASER DIAGNOSTIC PLASMA PROBE.

David O. Kingsland (General Electric Co., Radio Guidance Operation, Syracuse, N.Y.).

IEEE, Proceedings, vol. 53, Feb. 1965, p. 196.

Contract No. AF 19(628)-2378.

Demonstration of the feasibility of using Thomson scattered laser radiation to determine electron density in a helium plasma. The plasma generator used the cathode and grid elements of an industrial thyratron tube. In this application, this tube was filled with helium at a pressure of two mm Hg. The regular anode was replaced with one incorporating the desired optical windows and a unique retractable voltage probe. A figure shows the observed Thomson scattering as compared to a curve representing an electron density of  $2 \times 10^{15} \text{ cm}^{-3}$  and an electron temperature of  $3 \times 10^4 \text{ K}$ . The use of voltage probes to measure the axial potential gradient in the plasma during discharge gave a value of  $6 \times 10^{14} \text{ cm}^{-3}$  for the electron density when used with a knowledge of the discharge current and earlier well-established results. M.M.

#### A65-19619

##### REGULAR EMISSION FROM A MANY-ELEMENT LASER DURING THE PUMPING PULSE.

R. Pratesi and G. Toraldo di Francia (Firenze, Università, Istituto di Fisica Superiore, Florence, Italy).

IEEE, Proceedings, vol. 53, Feb. 1965, p. 196, 197. 5 refs.

USAF-sponsored research.

Observation of quasi-continuous emission or regular relaxation oscillations from a many-element ruby laser operating in a very few axial modes. The laser consisted of ten ruby rods with plane-parallel end faces, placed in series. In the case when regular emission was noticed, all the ruby faces were coated with three dielectric layers, corresponding to a reflectivity of about 65%. It is stated that, depending on the pumping level, it was possible to observe continuous emission or regular spiking during each pumping pulse and that, in general, this behavior was reproduced after random interchanges of the ruby rods. It is concluded that apparently, in the case of regular spiking, only very few frequencies (or a group of closely spaced frequencies) are strongly excited; other frequencies are present in the spectrum, but with much less intensity, and may be attributed to a short irregular transient. M.M.

#### A65-19622

##### LINEWIDTH AND INVERSION RATIO OF IRON-DOPED RUTILE.

C. Curtis Johnson and Larry E. Rouzer (NASA, Goddard Space Flight Center, Greenbelt, Md.).

IEEE, Proceedings, vol. 53, Feb. 1965, p. 204.

Experimental investigation of the suitability of iron-doped rutile ( $\text{Fe}^{3+} \cdot \text{TiO}_2$ ) for broadband maser applications. It is stated that optimum concentration studies have resulted in measured linewidths of 60 Mc and inversion ratios in excess of 15:1. A figure shows the experimental data taken at a center frequency of 4.0 Gc. The additional tests taken at other frequencies produced the same linewidths (60 Mc) as the typical data shown. It is noted that an advantage in the use of iron-doped rutile is the substantial reduction in the required magnetic field strength. This factor becomes significant when a superconducting magnet is employed in that it permits a simpler magnet design with a sizable reduction in magnet mass. Such a reduction facilitates a faster cool-down time when the maser-magnet system is cooled in a closed-cycle helium cryostat. M.M.

**A65-19623****RUBY LASER OSCILLATIONS MODULATED BY ULTRASONIC VIBRATION.**

Y. Sakai (Matsushita Research Institute Tokyo, Inc., Kawasaki, Japan).

*IEEE, Proceedings*, vol. 53, Feb. 1965, p. 204, 205.

Presentation of two additional features of ruby laser emission modulated in amplitude by applying ultrasonic vibrations. The schematic diagram of the experimental arrangement is shown. A 90°-oriented ruby rod 0.5 cm in diameter and 6.5 cm long was used. One end face of the rod was cut and polished to form a right-angle roof-type prism, while the other was polished to be flat and coated with multilayered dielectric film of 98% reflectivity. The rod was placed in a cylindrical mirror and energized at about 2000 joules by a Ushio MFT-524M helical Xe-flash tube. The stimulated emission, passing through a narrow-band interference filter peaked at 6943 Å and a set of neutral density filters, was guided into a LP22-type photomultiplier. The ultrasonic modulation effect on the undamped relaxation oscillation, displayed on a Tektronix Model 555 dual-beam oscilloscope, is shown, together with other features of the ultrasonic modulation effect on a CW-fashion oscillation.

M. M.

**A65-19628****MOTION SENSING BY OPTICAL HETERODYNE DOPPLER DETECTION FROM DIFFUSE SURFACES.**

R. D. Kroeger (Sperry Rand Corp., Sperry Gyroscope Co., Electro-Optics Group, Great Neck, N. Y.).

*IEEE, Proceedings*, vol. 53, Feb. 1965, p. 211, 212.

Contract No. AF 33(657)-11653.

Discussion of requirements and restrictions imposed on the optics of the system by the use of diffuse surfaces as the targets, in optical Doppler sensing using the highly coherent gas laser in an optical heterodyne system accomplished by moving (specular) mirrors over significant path lengths where most of the engineering problems are by now fairly well understood. It is stated that, to preserve the phase coherence in a Doppler shifted return resulting from target motion, it becomes necessary to reduce the receiver aperture so that only a few of the diffraction lobes are incident at the detector's photosurface. However, for the case of an unrestricted laser beam spot diameter at the target, the corresponding receiver aperture may become so small as to make it impossible to detect the received signal. Using a He-Ne laser operating at 6328 Å, a power output of 1.3 mw in the TEM<sub>00</sub> mode was obtained. Accounting for beam splitter and lens losses, the actual transmitted power was 0.6 mw. With this power it was possible to obtain useful Doppler signal at distances up to 180 ft with a Scotchlite semi-cooperative diffuse target and 35 ft with white bond paper.

M. M.

**A65-19682 \*****THE THEORY OF OSCILLATIONS OF A MOLECULAR-BEAM MASER [K TEORIY FLYUKTUATSIY MOLEKULARNOGO GENERATORA].**

V. B. Tsaregradskii (Gor'kovskii Gosudarstvennyi Universitet, Gorki, USSR).

*Radiofizika*, vol. 7, no. 6, 1964, p. 1075-1089. 20 refs. In Russian.

Study, based on the equations for an averaged polarization vector, of the effect of thermal and shot noise on the oscillations of a molecular-beam maser. The spectral densities of amplitude and frequency oscillations are determined. It is shown that the high stability and chromaticity of maser oscillations can be explained by the self-controlling action of the phase difference of the field and polarization.

J. R.

**A65-19683 \*****STATIONARY MODE OF A TW LASER AMPLIFIER WITH FEED-BACK [O STATSIONARNOM REZHIME KVANTOVOGO OPTICHESKOGO USLITELIA BEGUSHCHEI VOLNY S OBRATNOI SVIAZ'IU].**

N. D. Milovskii (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

*Radiofizika*, vol. 7, no. 6, 1964, p. 1095-1105. 15 refs. In Russian.

Investigation of the problem of transmission of plane electromagnetic waves through a layer of a nonlinear active medium. It is assumed that there is no reflection at the boundary of the active

layer, and a solution is sought in the form of a traveling wave with slowly varying phase and amplitude. The results obtained are used to determine both the amplification factor of a TW quantum amplifier and the amount of power radiated by a TW laser.

J. R.

**A65-19693 #****RADIATION DISPERSION IN A HELIUM-NEON LASER [RASKHODIMOST' IZLUCHENIYA V GELII-NEONOVOM LAZERE].**

V. I. Makhorin and E. D. Protsenko (Moskovskii Inzhenerno-Fizicheskii Institut, Moscow, USSR).

*Radiofizika*, vol. 7, no. 6, 1964, p. 1200-1203. In Russian.

Measurement of the dispersion of the output radiation of a helium-neon laser operating in the transition 3S<sub>2</sub>-2P<sub>4</sub> (λ = 6328 Å) when the distance between the mirrors is varied. Interference mirrors with a curvature radius of b = 2 m are used. The results obtained indicate that for resonators with spherical reflectors and small diffraction losses, quality can be improved, with practically no changes in dispersion, by increasing the distance between the mirrors. Several photographs of the field structure obtained during laser operation in the "two-beam" mode are included.

J. R.

**A65-19726****STABILITY OF TRAVELING WAVES IN LASERS.**J. A. White (National Bureau of Standards, Washington, D. C.). *Physical Review, 2nd Series*, vol. 137, Mar. 15, 1965, p. A 1651-A 1654.

Solution (to terms of fourth order in field strength) of the equations of motion for a fully quantized system of atoms interacting with traveling waves. Criteria are developed for the stability of traveling waves in solid and gaseous media. Expressions are given for the power outputs for both traveling and standing waves. The results for the latter agree with those obtained by Lamb in his semiclassical treatment of standing waves.

(Author) W. M. R.

**A65-19727****THEORY OF THE IONIZATION OF GASES BY LASER BEAMS.**

B. A. Tozer (Central Electricity Generating Board, Research Laboratories, Leatherhead, Surrey, England).

*Physical Review, 2nd Series*, vol. 137, Mar. 15, 1965, p. A 1665-A 1667. 8 refs.

Theoretical study of the rate of production of ions and free electrons by multiple photon excitation to the lowest level of the atom, with subsequent excitation to the ionization level. It is concluded that the experimentally observed gas breakdown under the action of a pulsed laser beam is probably initiated by this direct multiple absorption of photons, but that the subsequent growth of electron population is governed by some other process - e.g., inverse bremsstrahlung, or the acceleration of electrons in the oscillatory field. The theory predicts that the variation of threshold photon intensity for breakdown of a gas should exhibit almost pressure-independent low and high limits, that the range of intensities between these limits should be approximately  $(10^{13})^{1/N_p}$ , where  $N_p$  is the number of photons required to raise the atom to its lowest excited state, and that the threshold flux density will vary with change of focal volume as  $V^{-1/N_p}$ .

(Author) W. M. R.

**A65-19739 \*****THE PROBLEM OF INSTABILITY OF CONTINUOUS LASER RADIATION [PRO PROBLEMU NESTIKOSTI STATSIONARNOGO VIPROMINIUVANNIA LAZERA].**

V. S. Mashkevich (Akademiya Nauk Ukrain'skoi RSR, Institut Fiziki, Kiev, Ukrainian SSR).

*Ukrains'kii Fizicheskii Zhurnal*, vol. 10, Jan. 1965, p. 55-64. 9 refs. In Ukrainian, with summary in Russian.

Analysis, using a simple model to show that the kinetic equations can be used to describe the instability of CW-laser radiation. The physical nature of this instability is examined. Further, it is shown that the method of single-frequency oscillations in nonlinear systems with many degrees of freedom can be used to study the oscillations of laser radiation.

V. P.

**A65-19740 \***

**DYNAMICS OF LASER RADIATION WITH VARIABLE LOSSES. I** [DINAMIKA VIPROMINUVANNIA LAZERA ZI ZMINNENI VTRATAMI I].

G. Yu. Buriakivskii and V. S. Mashkevich (Akademiia Nauk Ukrainy'koi RSR, Institut Fiziki, Kiev, Ukrainian SSR). *Ukrainy'kii Fizichnyi Zhurnal*, vol. 10, Jan. 1965, p. 65-75. 5 refs. In Ukrainian, with summary in Russian.

Analysis of giant laser oscillations in the case of time-dependent resonator losses. The radiation of a three-level homogeneous system is examined on the basis of the kinetic equations, assuming a linear time-dependence of the resonator losses. Conditions for the onset of giant oscillations are formulated, and the minimum value of the rate of change in losses, at which giant oscillations can still occur, is determined. V. P.

**A65-19754**

**EXTENSION OF PLASMA INTERFEROMETRY TECHNIQUE WITH A He-Ne LASER.**

D. A. Baker, J. E. Hammel, and F. C. Jahoda (California, University, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.). *Review of Scientific Instruments*, vol. 36, Mar. 1965, p. 395, 396. 7 refs.

AEC-sponsored research.

Description of modifications to a method of Ashby and Jephcott for plasma diagnostics, by which the output intensity of a gas laser is modulated using phase variations in a portion of the output reflected back into the optical cavity. The plasma is placed between an He-Ne laser and a fixed external mirror. The He-Ne laser can operate simultaneously at two levels, and, at fixed pumping rate, the output of the two wavelengths is complementary, making it possible to monitor slow variations in one by variations in the other. The use of this system to study the fast plasma component of a plasma gun is discussed. P. K.

**A65-19849 \***

**A SIMPLIFIED CONSTRUCTION OF A HELIUM-NEON VISIBLE LASER.**

K. L. Vander Sluis, G. K. Werner, P. M. Griffin, H. W. Morgan, O. B. Rudolph, and P. A. Staats (Oak Ridge National Laboratory, Oak Ridge, Tenn.). *American Journal of Physics*, vol. 33, Mar. 1965, p. 225-240. 9 refs.

AEC-sponsored research.

Description of a simple, inexpensive dc-powered helium-neon laser with a 6328-Å output. The design is for a 60-cm confocal resonator with a few milliwatts of coherent power output and a rich mode structure. Details for the construction of the laser are discussed, including the selection and fabrication of equipment and parts, the design of the resonator and the amplifier tube, the equipment (including vacuum system) and procedures for preparing the amplifier tube, and the alignment procedure. Some variations to the basic design are suggested. The overall cost of the laser would be about three hundred dollars. (Author) P. K.

**A65-19993**

**PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON LASER PHYSICS AND APPLICATIONS [INTERNATIONALES SYMPOSIUM ÜBER DIE PHYSIK DER LASER UND DEREN ANWENDUNGEN].** (Schweizerische Kommission für Licht- und Elektronenoptik, and Universität Bern, Institut für angewandte Physik, Internationales Symposium über die Physik der Laser und deren Anwendungen, Bern, Switzerland, Oct. 12-15, 1964.) *Zeitschrift für angewandte Mathematik und Physik*, vol. 16, Jan. 25, 1965. 183 p.

CONTENTS:

PREFACE. K. P. Meyer and N. Schaetti, p. 3, 4.

GENERAL LASER PHYSICS.

OPTICS IN LASER RESEARCH. H. de Lang (Philips' Gloeilampenfabrieken, Eindhoven, Netherlands), p. 7-14. 15 refs. [See A65-19994 10-16]

NONLINEAR OPTICS AND RAMAN SCATTERING.

WAVE PROPAGATION IN NON-LINEAR MEDIA. L. J. F. Broer (Eindhoven, Technische Hogeschool, Eindhoven, Netherlands), p. 18-26. 5 refs. [See A65-19995 10-26]

GIANT PULSE LASERS AND STIMULATED RAMAN SCATTERING. R. W. Hellwarth, F. J. McClung, W. G. Wagner, and D. Weiner (Hughes Aircraft Co., Malibu, Calif.), p. 27-32. 11 refs. [See A65-19996 10-16]

SOLID STATE LASERS.

CRYSTALLINE SOLID STATE LASERS. D. W. Goodwin (Ministry of Aviation, Malvern, Worcs., England), p. 35-48. 13 refs. [See A65-19997 10-26]

SOLID STATE LASERS WITH CW EMISSION. K. Götts (Siemens und Halske AG, Munich, West Germany), p. 49-62. 21 refs. [See A65-19998 10-16]

GAS LASERS.

GAS LASERS. J. Haisma (Philips' Gloeilampenfabrieken, Eindhoven, Netherlands), p. 74-84. 22 refs. [See A65-19999 10-16]

INJECTION LASERS.

INJECTION LASERS. F. N. Hooge (Philips' Gloeilampenfabrieken, Eindhoven, Netherlands), p. 89-97. 50 refs. [See A65-20000 10-16]

CHEMICAL LASERS.

CHEMICAL LASERS. I. W. C. Nieuwpoort and R. Bleekrode (Philips' Gloeilampenfabrieken, Eindhoven, Netherlands), p. 101-106. 17 refs. [See A65-20001 10-16]

CHEMICAL LASERS. II. R. Bleekrode and W. C. Nieuwpoort (Philips' Gloeilampenfabrieken, Eindhoven, Netherlands), p. 107-110. 15 refs. [See A65-20002 10-16]

APPLICATIONS IN THE FIELD OF PHYSICS.

LASER APPLICATIONS IN THE FIELD OF PHYSICS AND OPTICS. J. M. Burch (National Physical Laboratory, Teddington, Middx., England), p. 111-119. 10 refs. [See A65-20003 10-16]

TESTING AND TREATING MATERIALS.

APPLICATION OF LASERS IN MATERIAL TESTING [ANWENDUNG VON LASERN BEI DER MATERIALUNTERSUCHUNG]. W. D. Hagenah (Institut für Spektrochemie und angewandte Spektroskopie, Dortmund, West Germany), p. 130-138. 38 refs. [See A65-20004 10-16]

APPLICATION OF LASERS TO THE TREATMENT OF MATERIALS [DIE ANWENDUNG DES LASERS FÜR DIE MATERIAL-BEARBEITUNG]. S. Panzer (Carl Zeiss, Oberkochen, West Germany), p. 138-155. 15 refs. [See A65-20005 10-16]

COMMUNICATION.

LASER APPLICATIONS TO COMMUNICATION. D. Sette (Rome, University, Rome, Italy), p. 156-169. 8 refs. [See A65-20006 10-07]

**A65-19994**

OPTICS IN LASER RESEARCH.

H. de Lang (Philips' Gloeilampenfabrieken, Philips Research Laboratories, Eindhoven, Netherlands). (Schweizerische Kommission für Licht- und Elektronenoptik, and Universität Bern, Institut für angewandte Physik, Internationales Symposium über die Physik der Laser und deren Anwendungen, Bern, Switzerland, Oct. 12-15, 1964.) *Zeitschrift für angewandte Mathematik und Physik*, vol. 16, Jan. 25, 1965, p. 7-14. 15 refs.

Description of laser experiments showing that laser radiation obeys all the laws of optical approximation in the same measure as ordinary light. Results obtained with a He-Ne laser having four plane reflectors are examined. A passive equiconfocal interferometer with a 1-m mirror separation and a reflectivity of 99%, designed to study the frequency spectra of gaseous lasers, is described. The theory of the eigenstates of polarization in a multiple-pass interferometer is reviewed and applied to several examples. V. P.



**A65-19996**

**GIANT PULSE LASERS AND STIMULATED RAMAN SCATTERING.**  
R. W. Hellwarth, F. J. McClung, W. G. Wagner, and D. Weiner  
(Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).  
(Schweizerische Kommission für Licht- und Elektronenoptik, and  
Universität Bern, Institut für angewandte Physik, Internationales  
Symposium über die Physik der Laser und deren Anwendungen,  
Bern, Switzerland, Oct. 12-15, 1964.)  
Zeitschrift für angewandte Mathematik und Physik, vol. 16,  
Jan. 25, 1965, p. 27-32. 11 refs.

Discussion of the design and principles of operation of a giant pulse laser, the high power of which greatly facilitates the observation of nonlinear effects. The application of a giant pulse laser to the investigation of a specific nonlinear effect - the stimulated Raman scattering - is discussed, with particular reference to a technique developed to measure the angle of emission of stimulated Raman scattering and the results obtained with it. V. P.

**A65-19997****CRYSTALLINE SOLID STATE LASERS.**

D. W. Goodwin (Ministry of Aviation, Royal Radar Establishment, Malvern, Worcs., England).  
(Schweizerische Kommission für Licht- und Elektronenoptik, and  
Universität Bern, Institut für angewandte Physik, Internationales  
Symposium über die Physik der Laser und deren Anwendungen,  
Bern, Switzerland, Oct. 12-15, 1964.)  
Zeitschrift für angewandte Mathematik und Physik, vol. 16,  
Jan. 25, 1965, p. 35-48. 13 refs.

Review of the theory of laser action in a crystalline optical solid. The performance of some promising materials is discussed in the light of this theory. The importance of multiphonon processes as they affect linewidth and transition probabilities is examined, and the theory is extended to resonant transfer processes. Specifically it is found that  $\text{Nd}^{3+}$  ions are essential for continuous operation at room temperature, and  $\text{Dy}^{2+}$  and  $\text{Tm}^{2+}$  ions at low temperatures. Likely effects of the host lattice upon laser action are outlined, and the importance of using optically isotropic crystals is demonstrated. V. P.

**A65-19998****SOLID STATE LASERS WITH CW EMISSION.**

K. Görs (Siemens und Halske AG, Research Laboratory, Munich, West Germany).  
(Schweizerische Kommission für Licht- und Elektronenoptik, and  
Universität Bern, Institut für angewandte Physik, Internationales  
Symposium über die Physik der Laser und deren Anwendungen,  
Bern, Switzerland, Oct. 12-15, 1964.)  
Zeitschrift für angewandte Mathematik und Physik, vol. 16,  
Jan. 25, 1965, p. 49-62. 21 refs.

Discussion of the oscillatory behavior of CW lasers, based on rate equations. The equations are taken in the form that applies to the four-level laser, and the analytical results obtained are compared with the experiment for a four-level laser using neodymium-doped  $\text{CaWO}_4$ . The problem of the damped periodic relaxation oscillations of the ruby laser is examined. Some results show that the continuously pumped laser using neodymium-doped  $\text{CaWO}_4$  is just as suitable for precision investigations as the gas laser. V. P.

**A65-19999****GAS LASERS.**

J. Haisma (Philips' Gloeilampenfabrieken, Philips Research Laboratories, Eindhoven, Netherlands).  
(Schweizerische Kommission für Licht- und Elektronenoptik, and  
Universität Bern, Institut für angewandte Physik, Internationales  
Symposium über die Physik der Laser und deren Anwendungen,  
Bern, Switzerland, Oct. 12-15, 1964.)  
Zeitschrift für angewandte Mathematik und Physik, vol. 16,  
Jan. 25, 1965, p. 74-84. 22 refs.

Discussion of the physical properties of the He-Ne laser, as a system representative of the various types of gas laser. The mechanism responsible for laser action by Ne atoms is described, and substantiated by test results. Particular attention is given to the following eight topics: the nonequilibrium state, the interaction

of several laser transitions with common levels, gain and saturation, optical cavities, tuning experiments and modes, the hole-burning effect, and nonlinear effects in gas lasers. V. P.

**A65-20001****CHEMICAL LASERS. I.**

W. C. Nieuwpoort and R. Bleekrode (Philips' Gloeilampenfabrieken, Philips Research Laboratories, Eindhoven, Netherlands).  
(Schweizerische Kommission für Licht- und Elektronenoptik, and  
Universität Bern, Institut für angewandte Physik, Internationales  
Symposium über die Physik der Laser und deren Anwendungen,  
Bern, Switzerland, Oct. 12-15, 1964.)  
Zeitschrift für angewandte Mathematik und Physik, vol. 16,  
Jan. 25, 1965, p. 101-106. 17 refs.

Discussion of the chemical laser, a device which has not yet been constructed. It is defined, from the point of view of energy conversion, as a device in which the input energy is solely chemical. Through the production of species in internally excited states which can lose their energy by radiation, a part of the chemical input energy is converted into radiative energy. The device will operate as a laser if the production rate of the excited species is sufficiently predominant to provide a medium with enough gain for one or more modes of some transition frequency to overcome the various losses of the optical cavity in which the reaction takes place. A simple model of the stationary "flame laser" type is examined for an understanding of the feasibility of chemical pumping in general and of the order of magnitude of the parameters involved. For this model it is found that (1) a lower limit, depending on flow velocity and wavelength, exists for the rate at which production and radiative processes develop and (2) the available gain can exceed appreciably the critical value required for laser action, if certain conditions are satisfied. The assumptions underlying the model are outlined, and the applicability of the results in practice is examined. V. P.

**A65-20002****CHEMICAL LASERS. II.**

R. Bleekrode and W. C. Nieuwpoort (Philips' Gloeilampenfabrieken, Philips Research Laboratories, Eindhoven, Netherlands).  
(Schweizerische Kommission für Licht- und Elektronenoptik, and  
Universität Bern, Institut für angewandte Physik, Internationales  
Symposium über die Physik der Laser und deren Anwendungen,  
Bern, Switzerland, Oct. 12-15, 1964.)  
Zeitschrift für angewandte Mathematik und Physik, vol. 16,  
Jan. 25, 1965, p. 107-110. 15 refs.

Continuation of the theoretical treatment of the chemical laser given in Part I, with particular reference to the problem of population inversions resulting from chemical reactions. The known population inversions in reactive systems are reviewed, proceeding from observations on atomic flames which have led to well-established sets of data on quantum-resolved chemical kinetics. V. P.

**A65-20003****LASER APPLICATIONS IN THE FIELD OF PHYSICS AND OPTICS.**

J. M. Burch (National Physical Laboratory, Teddington, Middx., England).  
(Schweizerische Kommission für Licht- und Elektronenoptik, and  
Universität Bern, Institut für angewandte Physik, Internationales  
Symposium über die Physik der Laser und deren Anwendungen,  
Bern, Switzerland, Oct. 12-15, 1964.)  
Zeitschrift für angewandte Mathematik und Physik, vol. 16,  
Jan. 25, 1965, p. 111-119. 10 refs.

Survey of some research applications of lasers, aimed at illustrating the way in which each application exploits the various laser properties. Among the applications noted which require extremely high spectral purity are the detection of very small effects, measurement of high absolute precision, and interferometric studies of very fast events. A number of interferograms of such events, obtained by various types of laser and laser arrangements, are presented. The applications noted requiring only the high brightness of the laser include long-distance alignment (improvement of target visibility), long-distance metrology (either by ranging or modulated carrier techniques), plasma diagnostics, high-speed photography, and the production of zone plates, gratings, and other

types of diffracting element by photographic or photomechanical use of a laser source. The interaction of laser research with other studies is examined.

V. P.

## A65-20004

## APPLICATION OF LASERS IN MATERIAL TESTING [ANWENDUNG VON LASERN BEI DER MATERIALUNTERSUCHUNG].

W. D. Hagenah (Institut für Spektrochemie und angewandte Spektroskopie, Dortmund, West Germany).

(Schweizerische Kommission für Licht- und Elektronenoptik, and Universität Bern, Institut für angewandte Physik, Internationales Symposium über die Physik der Laser und deren Anwendungen, Bern, Switzerland, Oct. 12-15, 1964.)

Zeitschrift für angewandte Mathematik und Physik, vol. 16, Jan. 25, 1965, p. 130-138. 38 refs. In German.

Discussion of the utilization of lasers for the determination of the chemical composition of materials by spectroscopic techniques. Several laser arrangements suitable for spectroscopic analysis are described, and some analytical problems which lend themselves particularly well to laser treatment are noted. The principles of the investigation of organic substances by means of stimulated Raman scattering and of plasma measurements by means of lasers are outlined.

V. P.

## A65-20005

## APPLICATION OF LASERS TO THE TREATMENT OF MATERIALS [DIE ANWENDUNG DES LASERS FÜR DIE MATERIALBEARBEITUNG].

S. Panzer (Carl Zeiss, Oberkochen, West Germany).

(Schweizerische Kommission für Licht- und Elektronenoptik, and Universität Bern, Institut für angewandte Physik, Internationales Symposium über die Physik der Laser und deren Anwendungen, Bern, Switzerland, Oct. 12-15, 1964.)

Zeitschrift für angewandte Mathematik und Physik, vol. 16, Jan. 25, 1965, p. 138-155. 15 refs. In German.

Review of the state of the art of metalworking processes in which the laser is used as a thermal tool. The phase-transformation processes involved in the conversion of laser radiation into heat are examined, and the problems associated with the use of lasers for removal of material and seam and point welding are discussed. High-speed photographs of laser-induced heating are presented, and photographs of the weld cross sections obtained in Cr-Ni steel with laser and electron beams are compared.

V. P.

## A65-20006

## LASER APPLICATIONS TO COMMUNICATION.

D. Sette (Rome, University, Bordini Foundation, Rome, Italy).

(Schweizerische Kommission für Licht- und Elektronenoptik, and Universität Bern, Institut für angewandte Physik, Internationales Symposium über die Physik der Laser und deren Anwendungen, Bern, Switzerland, Oct. 12-15, 1964.)

Zeitschrift für angewandte Mathematik und Physik, vol. 16, Jan. 25, 1965, p. 156-169. 8 refs.

Discussion of the properties of optical coherent waves suitable for purposes of communications. Directivity, energy transmission, absorption, information capacity, SNR, bandwidth, modulation, and the detection of signals carried by laser beams are examined and compared with radio-wave characteristics. Some general observations on long-distance laser communications systems are included.

V. P.

## A65-20059

## CONFERENCE ON CHEMICAL LASERS, UNIVERSITY OF CALIFORNIA, LA JOLLA, CALIF., SEPTEMBER 9-11, 1964, PROCEEDINGS.

Conference supported by the National Bureau of Standards, USAF, and the Navy.

Applied Optics, Supplement 2, 1965. 216 p.

## CONTENTS:

EDITORIAL FOREWORD. Kurt E. Shuler (National Bureau of Standards, Washington, D.C.), p. 1, 2.

INVERSION MECHANISMS IN GAS LASERS. W. R. Bennett, Jr. (Yale University, New Haven, Conn.), p. 3-33. 163 refs. [See A65-20060 10-16]

MEASUREMENT OF EXCITED STATE RELAXATION RATES. W. R. Bennett, Jr., P. J. Kindlmann, and G. N. Mercer (Yale University, New Haven, Conn.), p. 34-57. 109 refs. [See A65-20061 10-24]

PROPERTIES OF OPTICAL CAVITY MODES. A. G. Fox (Bell Telephone Laboratories, Inc., Holmdel, N.J.), p. 58.

COLLISION LASERS. Gordon Gould (TRG, Inc., Melville, N.Y.), p. 59-67. 15 refs. [See A65-20062 10-16]

CHARGE TRANSFER AS A POSSIBLE LASER PUMPING MECHANISM. J. William McGowan and R. F. Stebbings (General Dynamics Corp., San Diego, Calif.), p. 68-72. 19 refs. [See A65-20063 10-16]

HIGH-RESOLUTION TUNED-LASER SPECTROSCOPE. H. J. Gerritsen and M. E. Heller (Radio Corporation of America, Princeton, N.J.), p. 73-77. 13 refs. [See A65-20064 10-16]

A QUANTUM MECHANICAL EVALUATION OF LINE BREADTHS INVOLVED IN TUNED-LASER ABSORPTION AND STIMULATED EMISSION SPECTROSCOPY. W. R. Bennett, Jr. (Yale University, New Haven, Conn.), p. 78-80. 9 refs. [See A65-20065 10-16]

Nonequilibrium Chemical Excitation and Chemical Pumping of Lasers. Kurt E. Shuler, Tucker Carrington (National Bureau of Standards, Washington, D.C.), and John C. Light (Chicago, University, Chicago, Ill.), p. 81-104. 183 refs. [See A65-20066 10-16]

INVERTED POPULATION DISTRIBUTIONS PRODUCED BY CHEMICAL REACTIONS. H. P. Broida (California, University, Santa Barbara, Calif.), p. 105-108.

VIBRATIONAL-ROTATIONAL POPULATION INVERSION. J. C. Polanyi (Toronto, University, Toronto, Canada), p. 109-127. 106 refs. [See A65-20067 10-24]

MOLECULAR BEAM STUDIES OF INTERNAL EXCITATION OF REACTION PRODUCTS. D. R. Herschbach (Harvard University, Cambridge, Mass.), p. 128-144.

MEASUREMENT OF ENERGY TRANSFER IN MOLECULAR COLLISIONS. A. B. Callear (Cambridge, University, Cambridge, England), p. 145-170. 112 refs. [See A65-20068 10-24]

LASER POSSIBILITIES OF CHEMICALLY EXCITED MOLECULES FORMED WITH ATOMIC SPECIES. T. T. Kilmuchi (General Motors Corp., Santa Barbara, Calif.) and H. P. Broida (California, University, Santa Barbara, Calif.), p. 171-178. 30 refs. [See A65-20069 10-24]

FLAME LASER - MODEL AND SOME PRELIMINARY EXPERIMENTAL RESULTS. R. Bleekrode and W. C. Nieuwpoort (Philips' Gloeilampenfabrieken, Eindhoven, Netherlands), p. 179, 180. 6 refs. [See A65-20070 10-16]

POPULATION INVERSIONS PRODUCED BY CHEMICAL DEPLETION OF GROUND STATES. Michael L. Seman (Xerox Corp., Webster, N.Y.), p. 181-183.

EXPLOSION FLAME EMISSION. John A. Howe (Bell Telephone Laboratories, Inc., Murray Hill, N.J.), p. 184-186. 13 refs. [See A65-20071 10-33]

EXPLORATORY RESEARCH ON POPULATION INVERSIONS IN GASEOUS EXPLOSIONS. I. Wieder, R. R. Neiman, and A. P. Rodgers (Interphase Corporation-West, Palo Alto, Calif.), p. 187-192. 15 refs. [See A65-20072 10-33]

ATOMIC AND MOLECULAR FLUORESCENCE EXCITED BY PHOTODISSOCIATION. R. N. Zare (National Bureau of Standards, Boulder, Colo.) and D. R. Herschbach (Harvard University, Cambridge, Mass.), p. 193-200. 41 refs. [See A65-20073 10-24]

PHOTODISSOCIATION OF THALLIUM BROMIDE AND CESIUM BROMIDE. W. T. Walter and S. M. Jarrett (TRG, Inc., Melville, N.Y.), p. 201-204.

LASER ACTION IN RARE EARTH CHELATES. A. Lempicki, H. Samelson, and C. Brecher (General Telephone and Electronics Laboratories, Inc., Bayside, N.Y.), p. 205-213. 40 refs. [See A65-20074 10-26]

MECHANISM OF ENERGY TRANSFER IN SOME RARE-EARTH CHELATES. M. L. Bhaumik (Electro-Optical Systems, Inc., Pasadena, Calif.) and M. A. El-Sayed (Electro-Optical Systems, Inc., Pasadena, California, University, Los Angeles, Calif.), p. 214, 215. 6 refs. [See A65-20075 10-26]

**A65-20060****INVERSION MECHANISMS IN GAS LASERS.**

W. R. Bennett, Jr. (Yale University, Dunham Laboratory, New Haven, Conn.).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 3-33. 163 refs. USAF-Army-supported research.

Review of recent developments in the gas laser field, intended as a supplement to a previous, more detailed paper on the same subject. In addition, a number of new results are described. The following subjects are dealt with: (1) a summary of general laser considerations, (2) inversion saturation mechanisms in four-level systems, (3) possible two- and three-level collision lasers, (4) stimulated emission pumping, (5) transient inversions, and (6) ion lasers. Emphasis is placed on atomic systems, and a summary of currently known gas laser transitions is included as an appendix. (Author) M. M.

**A65-20061****MEASUREMENT OF EXCITED STATE RELAXATION RATES.**

W. R. Bennett, Jr., P. J. Kindlmann, and G. N. Mercer (Yale University, Sloane Physics Laboratory, New Haven, Conn.).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 34-57. 109 refs. USAF-supported research.

Detailed review of methods for the measurement of radiative decay rates and total inelastic destructive cross sections of short-lived excited states. The following subjects are considered: (1) methods of approximate calculation and interpretation of radiative and collision processes; (2) previous methods of measurement; (3) a review of delayed multichannel coincidence techniques; (4) properties of the vernier chronotron; (5) methods of statistical analysis; (6) a summary and analysis of data pertinent to laser transitions in He, Ne, and singly ionized Ar. The main emphasis is given to experimental techniques devised for the measurement of excited state lifetimes in the 4-nsec to 1000-nsec range and the analysis of data taken in the noble gases with this system. (Author) M. M.

**A65-20062****COLLISION LASERS.**

Gordon Gould (TRG, Inc., Melville, N.Y.).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 59-67. 15 refs. ARPA-sponsored research.

Consideration of the limitations caused by the efficiency and power output from gas discharge lasers by reliance on spontaneous emission to relax the lower level. The level spacing required for an untrapped radiative cascade places the laser levels well up in the energy level structure. The consequence is low quantum efficiency, a small fraction of electrons with the necessary energy for excitation, and parasitic loss through excitation of lower levels. A judicious combination of inelastic electron-atom and atom-atom collisions for excitation and relaxation can maintain a population inversion in appropriate atoms. This is said to be possible because transfer rates between levels due to atom-atom collisions are small if the energy defect substantially exceeds the average kinetic energy. Thus collisions with other atoms can selectively relax the lower level to other nearby levels without reducing the upper level population. In favorable cases, laser power of order 1 W/cm<sup>2</sup> is expected with an efficiency greater than 10%. Temperatures above 1000° are needed to produce a monatomic gas of most elements with suitably spaced low-lying levels. Two such elements are Mn and La. Mn can be contained in alumina tubing at 1350°, La in Ta tubing at 1800°. Diffusion to cold windows is prevented by a noble buffer gas. Apparatus for testing each of these systems has been constructed. Xe test oscillations have been observed in the apparatus at the working temperature. Measurements of fluorescence in the prospective laser transitions are being carried out. (Author) M. M.

**A65-20063****CHARGE TRANSFER AS A POSSIBLE LASER PUMPING MECHANISM.**

J. William McGowan and R. F. Stebbings (General Dynamics Corp., General Atomic Div., John Jay Hopkins Laboratory for Pure and Applied Science, San Diego, Calif.).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 68-72. 19 refs.

Consideration of the charge transfer between positive ions and neutral particles which, in general, will give rise to products in a variety of states. However, it is stated that recent measurements have shown that, in certain circumstances, particular excited states of either the neutral or charged product are highly favored. Charge transfer as it relates to the formation of excited products is briefly discussed. As a specific example of population inversion, the reaction  $H^+ + Cs \rightarrow H(n \geq 2) + Cs^+$  is discussed, and some of the possible implications of charge transfer pumping are considered.

(Author) M. M.

**A65-20064****HIGH-RESOLUTION TUNED-LASER SPECTROSCOPE.**

H. J. Gerritsen and M. E. Heller (Radio Corporation of America, RCA Laboratories, Princeton, N.J.).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 73-77. 13 refs.

Description of the technique of tuned-laser spectroscopy. Absorption data are given for methane and ethane in the region from 2947.8 cm<sup>-1</sup> to 2948.0 cm<sup>-1</sup> which were obtained using a helium-neon laser. It is stated that the large resolving powers available have made it possible to carry out the first absolute measurements of the collision diameters for methane-other gas collisions.

(Author) M. M.

**A65-20065****A QUANTUM MECHANICAL EVALUATION OF LINE BREADTHS INVOLVED IN TUNED-LASER ABSORPTION AND STIMULATED EMISSION SPECTROSCOPY.**

W. R. Bennett, Jr. (Yale University, Sloane Physics Laboratory, New Haven, Conn.).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 78-80. 9 refs. USAF-Army-supported research.

Analysis of collision- and power-broadening effects in tuned-laser absorption spectroscopy, using time-dependent perturbation theory. The results are compared with the earlier analysis based on the Lorentz theory of collision broadening given by Gerritsen and Heller. The analysis is extended to include similar broadening effects on the net gain coefficient when both stimulated emission and absorption are involved.

(Author) M. M.

**A65-20066****NONEQUILIBRIUM CHEMICAL EXCITATION AND CHEMICAL PUMPING OF LASERS.**

Kurt E. Shuler, Tucker Carrington (National Bureau of Standards, Washington, D.C.), and John C. Light (Chicago, University, Dept. of Chemistry and Institute for the Study of Metals, Chicago, Ill.).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 81-104. 183 refs.

Research supported by the Institute for Defense Analyses and NSF.

Review of chemical processes which give rise to atomic or molecular products with spectroscopically observable nonequilibrium distributions among internal energy levels. Relevant theoretical considerations are reviewed, and for several types of reactions, experimental results are discussed in terms of specific examples. It is stated that in several cases the existence of a population inversion seems clearly established, but it is by no means clear that the inversion density is sufficient for laser action. Certain features of molecular spectroscopy and collisional energy transfer processes bearing on the laser problem are discussed briefly.

(Author) M. M.

**A65-20067****VIBRATIONAL-ROTATIONAL POPULATION INVERSION.**

J. C. Polanyi (Toronto, University, Dept. of Chemistry, Toronto, Canada).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 109-127. 106 refs.

Research supported by the National Research Council of Canada and USAF.

Development of a general theory of partial and complete vibrational-rotational population inversion. It is stated that the requirement for stimulated emission in the R-branch is that the rotational quantum number  $J$  shall exceed a minimum value which depends in a simple fashion on the ratio of the rotational to the vibrational temperature ( $T_r/T_v$ ), both of which may be positive (partial inversion). Stimulated emission in the Q and R branches is only possible if  $T_v < 0$  (complete inversion). Features peculiar to a vibrational-rotational laser are discussed in terms of the equation for net gain. Rough upper limits are set on the power output from a chemical laser. The equations governing partial inversion are illustrated for the example of HCl. Processes (electric discharge, chemical reaction) which have produced partial population inversion, are discussed. The problem of maintaining complete population inversion is set out in terms of a hypothetical process forming CO continuously in level  $v = 7$  only. Physical processes which might excite a molecule into a high vibrational state, either by way of an electronically excited state (through fluorescence) or within the ground electronic state (through electronic - vibrational transfer, or through energetic impacts) are discussed. Chemical processes which might result in a greater probability for reaction into a higher vibrational state than a lower one,  $k_p' \gg k_p$ , are considered under three headings: attractive, mixed, and repulsive reactions: (1) in attractive reactions, it is supposed that the reagents attract but the products do not repel (significantly), the heat of reaction being trapped as vibration in the new bond; (2) in the mixed reactions, it is argued that there is a tendency for the repulsion to be dissipated while the new bond is still extended, as a result of which both repulsion and attraction could be converted to vibration in the new bond; (3) the repulsive reactions only appear likely to give  $k_p' \gg k_p$  in special circumstances, if the central atom is light or the repulsion impulsive. Examples are suggested in each category: (1) association reactions, (2) covalent - ionic reactions (e.g., alkali metal atom plus halogen or halide), (3) covalent reactions. It is noted that the second category shows particular promise of providing reactions suitable for use in a chemical laser. (Author) M. M.

**A65-20068****MEASUREMENT OF ENERGY TRANSFER IN MOLECULAR COLLISIONS.**

A. B. Callear (Cambridge, University, Physical Chemistry Laboratory, Cambridge, England).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 145-170. 112 refs.

Critical review of experimental data for four types of intermolecular energy transfer in the gas phase: (1) exchange of vibrational energy, (2) interchange of vibrational and electronic energy, (3) exchange of electronic energy, and (4) interchange of electronic and translational energy. The rate of exchange of vibrational energy between NO and a number of diatomic molecules has been measured by flash photolysis. It is stated that the probability of energy transfer decreases rapidly with increasing discrepancy between the vibrational frequencies of the two colliding molecules and that the results are in satisfactory quantitative agreement with predictions of the Schwartz, Slawsky, and Herzfeld theory. The spin-orbit relaxation of  $\text{Hg}(6^3\text{P})$ ,  $\text{Hg}(6^3\text{P}_1) + \text{M} \rightarrow \text{Hg}(6^3\text{P}_0) + \text{M}^*$ , was investigated by flash spectroscopy, and was shown to occur with  $\text{M} = \text{N}_2$ ,  $\text{CO}$ ,  $\text{H}_2\text{O}$ , or  $\text{D}_2\text{O}$ . There is no systematic variation of quenching cross section with the minimum energy which cannot be converted to vibration in the quenching molecule. It was suggested that, if a substantial transfer of electronic energy occurs - e.g.,  $\text{Na}(3^2\text{P}) + \text{M} \rightarrow \text{Na}(3^2\text{S}) + \text{M}^*$ , the yield of vibrational energy in the quenching molecule is generally small. Quenching occurs because of a strong interaction between  $\text{Na}(3^2\text{P})$  and M which permits near-crossing of potential curves in the collision complex. It was pointed out that the apparent electronic relaxation time of a metal atom in a shock-heated gas will be approximately equal to the vibrational relaxation

time if quenching produces a finite yield into any one of the vibrationally excited levels of the quenching molecule. Exchange of electronic energy between atoms was reviewed and it was shown that, to a first approximation, transfer occurs to minimize the change in internal energy. If several opportunities occur with  $\Delta E < 1000 \text{ cm}^{-1}$ , the course of the energy transfer cannot be predicted either from the magnitude of  $\Delta E$  or from the optical rules. The quenching of an excited atom by a polyatomic molecule depends on the reactivity of the latter, which again suggests that strong interaction facilitates transitions between potential surfaces in the collision complex.  $\text{Hg}(6^3\text{P}_0)$  is curiously stable to collisional deactivation. The probability of electronic-translational energy transfer was shown to decrease rapidly with increasing magnitude of the energy to be transferred. It was suggested that several types of energy transfer conform approximately to the law  $\log P = A\Delta E + B$ , where P is the probability of transfer per collision and  $\Delta E$  is the energy to be converted to translation. For fixed masses and temperature, A is the same constant for several different types of energy transfer, and B can be neglected except for vibrational exchange. (Author) M. M.

**A65-20069****LASER POSSIBILITIES OF CHEMICALLY EXCITED MOLECULES FORMED WITH ATOMIC SPECIES.**

T. T. Kikuchi (General Motors Corp., Defense Research Laboratories, Santa Barbara, Calif.) and H. P. Broida (California, University, Santa Barbara, Calif.).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 171-178. 30 refs.

ARPA-Navy-supported research.

Analysis of the factors influencing laser oscillation by the decay of excited molecules formed by a chemical reaction. The molecular system consists of three electronic levels, X, A, and B, listed in order of increasing excitation, of which the A level is preferentially populated by chemical reaction. Each of these states has its associated vibration-rotational levels. Effects of collision and rotational perturbation on depleting and on populating these levels are included in the analysis, which consists of solving the set of rate equations describing the growth of the various A and B states in conjunction with the condition for lasing. Electronically excited CN, ( $\text{CN}^*$ ), produced by an atomic nitrogen flame reaction is considered as an example. A possibility exists for lasing of  $\text{CN}^*$  at infrared and red wavelengths provided that the reaction is kept at low temperatures ( $\sim 77^\circ\text{K}$ ). Even then, it is necessary that the lower vibrational levels of the ground electronic state approach thermal equilibrium as soon as they are formed. A number of possible schemes for depleting the vibrational levels of the X states are discussed. (Author) M. M.

**A65-20070****FLAME LASER - MODEL AND SOME PRELIMINARY EXPERIMENTAL RESULTS.**

R. Bleekrode and W. C. Nieuwpoort (Philips' Gloeilampenfabrieken, Philips Research Laboratories, Eindhoven, Netherlands).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 179, 180. 6 refs.

Description of a simple model of a flame which reflects the characteristic requirements for the onset of laser action. A numerical example is given to demonstrate that a reasonable choice of the parameters used in the model leads to attainable pumping conditions. The reaction zone of low-pressure oxyacetylene flames is thought to be a suitable source of excitation of atoms and molecules. Excitation conditions of interesting species in this type of flame are briefly discussed together with recent experimental results. (Author) M. M.

**A65-20073****ATOMIC AND MOLECULAR FLUORESCENCE EXCITED BY PHOTODISSOCIATION.**

## A65-20074

R. N. Zare (National Bureau of Standards and Colorado, University, Joint Institute for Laboratory Astrophysics, Boulder, Colo.) and D. R. Herschbach (Harvard University, Dept. of Chemistry, Cambridge, Mass.).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 193-200. 41 refs. AEC-supported research.

Consideration of molecular photodissociation which often produces fluorescence from electronically excited fragment atoms or molecules and of the possibility of maser action for some systems. The factors which govern the fluorescence line strength and the Doppler width are briefly discussed. Some qualitative features of dissociative electron impact processes are compared with photodissociation. A bibliography of photodissociation processes which lead to electronically excited species is included.

(Author) M. M.

## A65-20074

### LASER ACTION IN RARE EARTH CHELATES.

A. Lempicki, H. Samelson, and C. Brecher (General Telephone and Electronics Laboratories, Inc., Bayside, N.Y.).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 205-213. 40 refs. ARPA-Navy-DOD-supported research.

Review of the work on chelate lasers, with emphasis on the chemistry of the chelates, the spectroscopic properties of these compounds, and the properties of the laser. The discussion of the chemistry centers about the coordination found in these compounds and the species present in solution. The spectroscopic properties of the various species are compared from the point of view of achieving laser action. The kinetics of the fluorescence are discussed, and the calculation of the threshold for laser action is given. The characteristics of the laser output are described for different cavity geometries.

(Author) M. M.

## A65-20075

### MECHANISM OF ENERGY TRANSFER IN SOME RARE-EARTH CHELATES.

M. L. Bhaumik (Electro-Optical Systems, Inc., Pasadena, Calif.) and M. A. El-Sayed (Electro-Optical Systems, Inc., Pasadena; California, University, Dept. of Chemistry, Los Angeles, Calif.).

(Conference on Chemical Lasers, University of California, La Jolla, Calif., Sept. 9-11, 1964.)

Applied Optics, Supplement 2, 1965, p. 214, 215. 6 refs. USAF-supported research.

Discussion of the mechanism of energy transfer in rare-earth chelates, with a view to their application as laser material. It is shown that the optical pumping by energy transfer in some rare-earth  $\beta$ -diketone chelates does not involve any inefficient process, although the energy migration occurs via the lowest triplet level of the ligand.

(Author) M. M.

## A65-20241

### INITIAL ENERGIES OF LASER-INDUCED ELECTRON EMISSION FROM W.

Walter L. Knecht (USAF, Systems Command, Research and Technology Div., Avionics Laboratory, Wright-Patterson AFB, Ohio).

Applied Physics Letters, vol. 6, Mar. 15, 1965, p. 99, 100. 5 refs.

Observation of high initial energies of electrons from tungsten illuminated by a Q-switched ruby laser. In the experiment described, the tungsten formed the cathode of a high-vacuum diode with a Kovar cylinder anode and a flat window. The generated diode signal showed an electron emission pattern with two peaks rather than a single peak per laser pulse. The first peak followed the laser pulse almost faithfully. The second peak trailed the laser pulse. The peaks had distinct ranges of rise and decay times. It is stated that the electron emission pattern of the signal does not change markedly when the tungsten target is moved by a few millimeters along its perpendicular axis. The pattern changes drastically, however, when the angle of the laser beam incident upon the tungsten target is changed by a few degrees. The observed changes are shown. It is noted that the analysis of the nature of the process underlying the electron emission pertaining to the first peak of the signal can be based on the following evidence: (1) the process is an instantaneous process. Electrons are emitted at the

instant of laser beam impact; (2) the electrons possess high initial energies; and (3) the angle of the incident laser beam has a distinct effect upon the electron emission pattern of the signal. It is stated that this evidence seems to support the suggestion that the process can be identified as a direct laser field action.

M. M.

## A65-20260 #

### ANOMALOUS DISPERSION OF LIGHT IN THE R LINES OF RUBY AND THE REFRACTION SHIFT OF THE SPECTRUM PRODUCED BY A LASER.

I. S. Gorban and G. L. Kononchuk.

(Optika i Spektroskopiia, vol. 17, Dec. 1964, p. 880-886.)

Optics and Spectroscopy, vol. 17, Dec. 1964, p. 478-481. 8 refs. Translation.

## A65-20263 #

### THE 3.5 $\mu$ Xe-He LASER.

E. P. Markin and V. V. Nikitin.

(Optika i Spektroskopiia, vol. 17, Dec. 1964, p. 953, 954.)

Optics and Spectroscopy, vol. 17, Dec. 1964, p. 519. Translation.

## A65-20326 #

### THEORY OF A CONTINUOUSLY OPERATING LIGHT GENERATOR - LASER.

A. L. Mikaelian, M. L. Ter-Mikaelian, and Iu. G. Turkov.

(Radiotekhnika i Elektronika, vol. 9, Aug. 1964, p. 1357-1367.)

Radio Engineering and Electronic Physics, vol. 9, Aug. 1964, p. 1119-1127. 11 refs. Translation.

## A65-20343 #

### EXPERIMENTAL INVESTIGATION OF THE ENERGY CHARACTERISTICS OF A RUBY LASER.

A. L. Mikaelian, V. M. Gardash'ian, N. A. Sakharova, and Iu. G. Turkov.

(Radiotekhnika i Elektronika, vol. 9, Aug. 1964, p. 1542-1545.)

Radio Engineering and Electronic Physics, vol. 9, Aug. 1964, p. 1275-1278. Translation.

## A65-20510 #

### MEASUREMENT OF FLUCTUATIONS OF OSCILLATION FREQUENCY BY THE DELAY-LINE METHOD.

V. S. Letokhov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Radiotekhnika i Elektronika, vol. 9, Sept. 1964, p. 1628-1633.)

Radio Engineering and Electronic Physics, vol. 9, Sept. 1964, p. 1344-1349. 7 refs. Translation.

## A65-20744

### ATOMIC RELAXATION AND FLUCTUATIONS OF LASER PHOTONS.

Jack Sarfatti (Photonics, Shaker Heights, Ohio).

Optical Society of America, Journal, vol. 55, Apr. 1965, p. 455,

456. 6 refs.

Use of the fundamental rules of adding probability amplitudes in quantum mechanics to provide insight into the emission of photons by multiple-atom systems, and thus determine if there is a maximum mean number of photons that a laser can generate into a single coherent state per unit time. A diagram is presented showing the ensemble-averaged mean-square deviation of the photon count, normalized to pure shot noise for a fixed observation time, as a function of photon output of a laser. The critical power can be estimated by solution of an exponential-growth equation. F.R.L.

## A65-20909

### THE POSSIBILITY OF USING COMBINED RESONANCE TO PRODUCE A MASER EFFECT.

E. I. Rashba (Akademiia Nauk Ukrainskoi SSR, Institut Poluprovodnikov, Kiev, Ukrainian SSR).  
(Fizika Tverdogo Tela, vol. 6, Oct. 1964, p. 3178, 3179.)  
Soviet Physics - Solid State, vol. 6, Apr. 1965, p. 2538, 2539.  
15 refs. Translation.

#### A65-20913 \*

CONTRIBUTION TO THE PROBLEM OF STABILITY OF A GIANT-PULSE LASER [DO PITANNIA PRO STIKIST' NADSVITLOVOGO OSTSILLATORA].

M. I. Kheifets (Akademiia Nauk Ukrainskoi SSR, Fiziko-Tekhnichnii Institut, Kharkov, Ukrainian SSR).  
Ukrains'kii Fizichnii Zhurnal, vol. 10, Feb. 1965, p. 128-134.  
7 refs. In Ukrainian.

Derivation of expressions for the effects of radiative reaction on a giant-pulse laser in an anisotropic medium. Analytical equations are provided which describe these effects in the absence of dispersion. From the equations it is apparent that under certain conditions radiation at normal and abnormal Doppler frequencies may vanish or lead to changes in the oscillations. V. Z.

#### A65-21041

SPECTRUM OF A RUBY LASER WITH EXTERNAL SPHERICAL MIRRORS.

V. K. Koniukhov, L. A. Kulevskii, A. M. Prokhorov, and A. K. Sokolov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Akademiia Nauk SSSR, Doklady, vol. 158, Oct. 11, 1964, p. 824-826.)

Soviet Physics - Doklady, vol. 9, Apr. 1965, p. 875-877. 12 refs. Translation.

#### A65-21056 \*

GENERATION OF LIGHT HARMONICS IN SEMICONDUCTORS AND DIELECTRICS NEAR THE EDGE OF THE ABSORPTION BAND [O GENERATSII SVETOVYKH GARMONIK V POLUPROVODNIKAKH I DIELEKTRIKAKH VBLIZI KRAIA POLOS Y POGLOSHCHENIIA].

A. M. Afanas'ev and E. A. Manykin (Moskovskii Inzhenerno-Fizicheskii Institut, Moscow, USSR).  
Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Feb. 1965, p. 483-487. 5 refs. In Russian.

Analysis of the effect of formation of the second harmonic in the passage of laser light through a CdS crystal at temperatures of 20° to 300°C. This effect has been observed and studied by Miller, Kleinman, and Savage. Near the edge of the absorption band there occurs an increase in both the absorption and generation of the second harmonic, the source of which is a strong monochromatic electromagnetic wave of the fundamental frequency. It is shown that the absorption and generation depend in equal measure on the frequency, so that the resulting intensity of the second harmonic does not change appreciably. The intensity of the second harmonic depends on which of the two processes prevails. The results of the analysis are extended to the formation of the third harmonic in a gas. V. P.

#### A65-21070 \*

STATISTICS OF OPTICAL-LASER EMISSION [O STATISTIKE IZLUCHENIIA OPTICHESKOGO KVANTOVOGO GENERATORA].

V. S. Letokhov and E. P. Markin (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Feb. 1965, p. 770, 771. In Russian.

Discussion of an experimental procedure developed to measure the probability density amplitude of the electric component of a laser radiation field. The amplitude distributions of the beat signals measured for oscillations at two different frequencies are presented in graphical form. V. P.

#### A65-21071 \*

CHANGE IN NATURE OF RUBY-LASER RADIATION UNDER THE EFFECT OF PHthalocyanine SOLUTIONS PLACED IN THE RESONATOR CAVITY [IZMENENIE KHARAKTERA IZLUCHENIIA OPTICHESKOGO GENERATORA NA RUBINE POD VLIANIEM RASTVOROV FTALOTSIANINOV, POMESHCHENNYKH V REZONATOR].

V. N. Gavrilov, Iu. M. Griaznov, O. L. Lebedev, and A. A. Chastov.

Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Feb. 1965, p. 772, 773. In Russian.

Experimental investigation of the effect of concentration of several phthalocyanine solutions on the radiation of a ruby laser. Oscillograms of laser radiation for phthalocyanine solutions of various optical density are given, together with an oscillogram of a single impulse for a specific phthalocyanine solution. The oscillograms demonstrate that the otherwise random pulsations of the output radiation appear as one or several short intensive impulses, the number of which increases with increasing transparency of the solution. V. P.

#### A65-21077

PROSPECTS FOR OPTICAL COMMUNICATION IN SPACE.

B. C. Bowers (Plessey Co. /UK/, Ltd., Roke Manor, Herts., England).

British Communications and Electronics, vol. 12, Apr. 1965, p. 222-227. 14 refs.

Review of the possibilities for optical communications using lasers in space, with emphasis on the natural limitations involved. Difficulties associated with space optical communications are discussed, and include background sunlight and the need for a highly stable transmitter platform. For a Moon-to-Earth communication system, the stability problems are almost eliminated, and design considerations for such a system are discussed. These include limitations of laser power and bandwidth, and SNR and minimum detectable-signal requirements. P. K.

#### A65-21168

SPECTROSCOPIC PROPERTIES OF ACTIVATED LASER CRYSTALS. III.

P. Görrlich, H. Karraas, G. Köstitz, and R. Lehmann.

Physica Status Solidi, vol. 8, Feb. 1, 1965, p. 385-429. 254 refs.

Discussion of work on materials and operating procedures for lasers. Spectroscopic data on absorption, spontaneous fluorescence, and stimulated emission in actinides, transition-metal, and semiconductor laser materials are presented. Laser arrangements, and procedures for light pumping, for the modulation and determination of input and output power, and for testing for absorption and fluorescence are described. The general optical and thermal properties of laser optical media are reviewed. An extensive bibliography is included. P. K.

#### A65-21256

A SMALL, STABLE GAS LASER.

J. Haisma, S. J. van Hoppe, H. de Lang, and J. van der Wal (Philips' Gloeilampenfabrieken, Philips Research Laboratories, Eindhoven, Netherlands).

(Philips Technical Review, vol. 24, no. 3, 1962-1963.)

Microtecnica, vol. 18, Dec. 1964, p. 313-315. 5 refs.

Description of a small (10-cm active gas column) He-Ne gas laser. The laser consists of a heavy cylindrical block of fused quartz with ends polished flat to within 0.1  $\mu$  and with a hole 3 mm in diameter bored along the axis. Two fused-quartz blocks, polished to even closer limits and provided with interference mirrors (99% reflective in IR), are placed against the end of the cylinder where they give a vacuum-tight seal by adhesion alone. Charged with 85% He and 15% Ne (pressure 3 torr), the laser is excited by a dc voltage between two electrodes. Photographs of various patterns of mode excitation are given; the patterns were viewed by applying the laser output to a lead-oxide vidicon which in turn produces an output which can be viewed on closed-circuit TV. D. H.

#### A65-21299

UNSTABLE OPTICAL RESONATORS FOR LASER APPLICATIONS.

A. E. Siegman (Stanford University, Dept. of Electrical Engineering, Stanford, Calif.).

IEEE, Proceedings, vol. 53, Mar. 1965, p. 277-287. 23 refs.

Contracts No. AF 33(615)1411; No. DA-36-039-SC-90839.

Simple geometrical analysis which describes the lowest-order transverse mode of any large-Fresnel-number optical resonator located in the unstable or high-loss region of the resonator mode

chart. Such resonators include, for example, resonators in which one or both of the mirrors are divergent spherical surfaces. The lowest mode in such a resonator is assumed to consist of two oppositely traveling divergent spherical waves which uniformly illuminate the end mirrors. The centers of curvature of these spherical waves do not, in general, coincide with the mirror centers of curvature, but are found by requiring that each center be the image of the other upon reflection from the appropriate mirror. The resonator losses are found from purely geometrical considerations, and are given by simple analytical expressions. These losses turn out to be independent of the mirror sizes, so that hyperbolic universal equi-loss contours can be drawn on the resonator mode chart. The losses are said to agree well with more exact results obtained by Fox and Li for a few specific cases. Experimental results in good agreement with the analysis have been obtained using a ruby laser rod having a divergent spherical surface ground directly onto one end of the laser rod. Unstable resonators, particularly the Cassegrainian unstable configuration used in the experiments, appear potentially useful for diffraction output coupling applications, and possibly also for transverse mode control, in ruby and other high-gain lasers. (Author) M.M.

#### A65-21300

##### A PROPOSED NOVEL METHOD FOR OBTAINING A NONSPIKING PULSED LASER.

R. H. Pantell and H. E. Puthoff (Stanford University, Stanford, Calif.).

IEEE, Proceedings, vol. 53, Mar. 1965, p. 295. 9 refs.

Discussion of an approach to suppressing pulsed laser spiking. It is shown that the establishment of the proper initial conditions leads to a nonspiking output, and, in particular, a proposed method for implementing this approach is presented. The proposed technique for eliminating spiking consists of providing the equilibrium photon density as threshold is reached. With this initial condition satisfied, spiking will not occur. This can be accomplished by using an auxiliary initiating laser which reaches threshold before the main laser. One possible configuration for obtaining the required initial photon density is shown. It consists of a segmented ruby rod composed of two sections, one of which has a lower threshold such as might be obtained by using a composite or clad rod. It is noted that the experimental results of several investigators indicate that the proposed method of operation is feasible. Of particular interest are the results on coupled lasers by Koester et al., who were interested in the switching of neodymium-doped glass lasers for use as computer elements. They observed that, when one laser was coupled to another, the initial transient of the second was greatly reduced, and quenching of the first laser took place. It is pointed out that, although these results were not explained, it is reasonable to believe that they are a consequence of the mechanism described. This indicates that the control of spiking in a pulsed ruby laser can be accomplished by the suggested procedure and would result in a compact device requiring no external circuitry. M.M.

#### A65-21303

##### SATELLITE LASER RANGING EXPERIMENT.

G. L. Snyder, S. R. Hurst, A. B. Grafinger, and H. W. Halsey (General Electric Co., Missile and Space Div., King of Prussia, Pa.).

IEEE, Proceedings, vol. 53, Mar. 1965, p. 298, 299.

Discussion of laser ranging experiments performed with the Beacon Explorer B (S-66) satellite during the period from Oct. 9, 1964 to Nov. 8, 1964. The data obtained were in the form of an entire time history of the received signal recorded on an oscilloscope camera with Polaroid Type-410 film. A figure shows the best picture of a laser signal return from the satellite that was obtained during the experimental period. At the range of the satellite, there exists a characteristic pulse. The signature of the laser return is due to the double pulse nature of the transmitted laser signal as shown in a figure. Return signals were not observed for all cases when the conditions would have predicted a return. It is stated that, although the cause for this is not known at this time, the effect is not unreasonable if the nonuniformity of the laser beam and the nonuniformity of the return beam from the satellite corner reflectors are considered. The mode of operation was to point the

laser ranging system at points, separated by one minute of time, on the satellite ephemeris as supplied by NASA-GSFC. The equipment used is shown. It is noted that the initial results lend support to the techniques used in the analysis of the system design and demonstrate the feasibility of the construction of an operating laser tracking system for satellites. M.M.

#### A65-21306

##### REFLECTION OF RUBY LASER RADIATION FROM EXPLORER XXII.

H. H. Plotkin, T. S. Johnson, P. Spadin, and J. Moye (NASA, Goddard Space Flight Center, Greenbelt, Md.).

IEEE, Proceedings, vol. 53, Mar. 1965, p. 301, 302.

Description of reflected radiation detected from the Orbiting Beacon Explorer-B satellite, after it was illuminated by a Q-spoiled ruby laser. The laser transmitter and telescope receiver were both mounted on a single pedestal of a modified Nike-Ajax radar system. In a figure, the first and third traces show laser reflections received on the morning of Oct. 31, 1964, while the satellite was approaching its closest point, which would have corresponded to a time of flight of 6.25 ms. The system had the following approximate parameters: each laser burst had a total energy of 0.8 joule contained within a divergence cone 1.2 milliradians in diam.; the satellite had an effective retroreflecting area of about 100 cm<sup>2</sup> when viewed in the direction from which it was seen during the observations; due to a combination of diffraction effects and prism imperfections, light is reflected back from the cube-corner array in a divergence cone 0.1 milliradian in diam. at 35% intensity; the receiver was a 16-in.-diam., 300-in. focal length telescope, a 10-Å bandwidth interference filter, and a 9558-Å photomultiplier. It is noted that these values would lead to an expected signal of about 450 photoelectrons at a range of 1000 km, or about the same size as the observed signals. M.M.

#### A65-21321

##### SINGLE MODE DIFFERENTIAL EFFICIENCY FOR CIRCULAR AND RECTANGULAR LASER DIODES.

A. C. Scott (Wisconsin, University, Dept. of Electrical Engineering, Madison, Wis.).

IEEE, Proceedings, vol. 53, Mar. 1965, p. 315, 316.

NSF-supported research.

Discussion of expressions derived for the single mode outside differential quantum efficiency of the circular and rectangular geometries of laser diodes. The function for the circular diode is plotted in a figure for various ratios of radius to wavelength and compared with the corresponding relation for linear diodes. It is noted that considerably higher efficiency is predicted for the circular diode at lower values of reflectivity. This may have been observed by Arnold and Mayburg and occurs because a circular diode has twice the ratio of emitting edge to surface area as a linear diode with the same threshold current density. Circular diodes are less efficient at large values of reflectivity because the electric field amplitude becomes proportionately greater at the origin where it does not contribute to output. M.M.

#### A65-21324

##### IMPROVED MASER PERFORMANCE THROUGH PUMP MODULATION.

R. D. Ray (Radio Corporation of America, Defense Electronic Products, Dept. of Applied Research, Camden, N.J.).

IEEE, Proceedings, vol. 53, Mar. 1965, p. 318, 319.

Discussion of the possibility of anticipating improved maser performance through gain stability if pump fluctuations are kept to a minimum by the elimination of two of four variables. Regulating the pump frequency by stabilizing the temperature of the associated klystron can be expensive, cumbersome, and even unreliable. However, since there is a relaxation time  $T$  associated with the pump transition, it is desirable to take an opposite point of view and rapidly vary the pump frequency about the desired frequency. As an example, a klystron with more than twice the power needed for saturation, a 200-Mc electronic tuning range and modulated at a rate  $> 1/T$ , is considered. A table enumerates some gain stability measurements with a comparison of modulated and CW operating modes. It is noted that frequency-modulating the pump also resulted in improved maser performance by increasing gain and bandwidth. A possible explanation is provided. It is pointed out

that another advantage accrues from the use of a swept pump. For the conventional case of a single unswept pump, an appropriate maser might give an instantaneous bandwidth of 10 Mc or less. Measurements made while using a modulated klystron with a 200-Mc electronic tuning range show the instantaneous bandwidths possible with one pump to be 40 Mc at S-band and 80 Mc at C-band. This is demonstrated in figures. M.M.

#### A65-21326

##### NONMECHANICAL SCANNING OF LIGHT IN ONE AND TWO DIMENSIONS.

R. Lipnick, A. Reich, and G. A. Schoen (Lockheed Aircraft Corp., Lockheed Electronics Co., Military Systems Div., Plainfield, N.J.).

IEEE, Proceedings, vol. 53, Mar. 1965, p. 321.

Consideration of laboratory work which has demonstrated fairly large-angle nonmechanical scanning of light, in one and two dimensions, through optical refraction by traveling acoustic waves. It is stated that, for appropriate values of light beamwidth and acoustic frequency and with a suitable acoustic medium, substantial angular deflections can be obtained in a single pass of the light beam through the scanner. An acoustic scanner capable of deflecting in one and two dimensions was constructed and is shown. The transducers were X-cut quartz resonant at one Mc. The light source was the 6328-Å line of a helium-neon laser, with a beamwidth of 2 mm. One-dimensional deflection achieved with the acoustic scanner is shown. The acoustic medium in this instance was silicone fluid and the optical path through the acoustic beam was 1.5 cm. It is stated that, when the two orthogonal transducers of the scanner are simultaneously excited, orthogonally propagating acoustic waves are generated. The light beam traverses the line of intersection of the propagating acoustic beams, and the acoustic beams exert their effects independently upon the light. Therefore, the light beam is deflected independently in each orthogonal direction. The number of resolution elements can be increased both by increasing the acoustic beam intensity and by decreasing the undeflected light beam diam. It is pointed out that the deflection angles discussed can be greatly increased by using post scanner divergent optics; however, the achievable resolution elements are not increased by this artifice. M.M.

#### A65-21335

##### INFRARED LASER PREAMPLIFIER SYSTEM.

F. Arams and M. Wang (Cutler-Hammer, Inc., Airborne Instruments Laboratory Div., Deer Park, N.Y.).

IEEE, Proceedings, vol. 53, Mar. 1965, p. 329. 8 refs.

Investigation of the use of an He-Ne laser preamplifier with substantial high gain. It utilized the very high gain transition at  $\lambda = 3.39 \mu$ , thereby permitting operation without regenerative reflectors and thus yielding amplification over the full Doppler line-width. Measured improvements in the minimum detectable signal of 45 db (gross) and 32 db (net) were obtained relative to a room-temperature PbS detector. No amplifier noise was observed in the experiments and none should have been detectable as the analysis which is provided indicates. A 1.2-meter He-Ne laser tube without reflectors was employed. The measured electronic gain of 45 db is said to be in reasonable agreement with the values reported. A 3.39- $\mu$  oscillator chopped at 1.4 Gc was used as the coherent source. The detector was followed by a tuned amplifier with  $\Delta f = 72$  cs. A measurement was also made of the net sensitivity improvement due to the laser. A 32-db net improvement was measured when, at the detector aperture plane, the laser amplifier was substituted which had nearly equal aperture area, and was followed by the same PbS detector. M.M.

#### A65-21379

##### RELATION BETWEEN QUANTUM AND SEMICLASSICAL DESCRIPTION OF OPTICAL COHERENCE.

C. L. Mehta (Rochester, University, Dept. of Physics and Astronomy, Rochester, N.Y.) and E. C. G. Sudarshan (Bern, University, Institute for Theoretical Physics, Bern, Switzerland). (Conference on Quantum Electrodynamics of High Intensity Photon Beams, Durham, N.C., Aug. 1964.)

Physical Review, 2nd Series, Section B, vol. 138, Apr. 12, 1965, p. B274-B280. 14 refs.

Army-supported research.

Re-examination of the problem of relating the semiclassical and quantum treatments of statistical states of an optical field. The case where the rule of association between functions and operators is that of antinormal ordering is studied in detail. It is shown that the distribution function for each mode corresponding to this case is a continuous bounded function and is also a boundary value of an entire analytic function of two variables. The nature of the distribution for the normal-ordering rule of association and its relation to this entire function are discussed. It is shown that this distribution can be regarded as the limit of a sequence of tempered distributions in the following sense: One can find a sequence of density operators  $\hat{\rho}(\nu)$  which converges in the norm to the density operator  $\hat{\rho}(\nu)$  of any given field (consisting of a single mode), such that each member of the sequence can be expressed in the form  $\hat{\rho}(\nu) = \int \Phi(\nu)(z) |z\rangle\langle z| d^2z$ , where  $\Phi(\nu)$  is a tempered distribution. (Author) A. B. K.

#### A65-21617

##### ELECTROLUMINESCENCE AND LASING ACTION IN GaAs<sub>1-x</sub>P<sub>x</sub>.

M. Pilkuhn and H. Rupprecht (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N.Y.).

Journal of Applied Physics, vol. 36, Mar. 1965, p. 684-688. 26 refs. Navy-ARPA-DOD-supported research.

Study of the electroluminescence of Zn diffused diodes in forward and reverse bias. Emission spectra obtained for forward biasing showed a near-edge as well as a low-energy line. In the composition range  $x > 0.55$ , where the lowest conduction band minimum is at  $k = 0$ , most photons are emitted in the near-edge line. Lasing action could be observed in this range, and the shortest wavelength where stimulated emission was obtained at 77°K was 6380 Å. For  $x < 0.55$ , where the lowest conduction band minimum is the (100) minimum, the low-energy emission becomes dominant. The energy separation between near-edge and low-energy line varies between 0.4 and 0.47 ev at 77°K depending on the composition. This suggests that the same defect is responsible for the low-energy emission in all these diodes (including GaAs and GaP). In reverse bias, near-edge emission and emission at higher energies than bandgap could be observed for  $x < 0.55$ . The cutoff energy of the emission on the high-energy side was measured as a function of composition. It was found to vary in a manner similar to the variation of the energy of the (000) conduction band minimum. The external quantum efficiency of the forward bias emission drops sharply by two orders of magnitude at the composition  $x = 0.55$  when  $x$  is decreased. The efficiency of the reverse bias emission is independent of composition. (Author) D. H.

#### A65-21620

##### STABILIZATION OF THE He-Ne MASER ON THE ATOMIC LINE CENTER.

Koichi Shimoda and Ali Javan (Massachusetts Institute of Technology, Dept. of Physics, Cambridge, Mass.).

Journal of Applied Physics, vol. 36, Mar. 1965, p. 718-726. 5 refs. NASA-supported research.

Application of an automatic feedback control for long-term frequency stabilization of an He-Ne laser at the center frequency of the atomic resonance. The length of the Fabry-Perot resonator is modulated at a low frequency with small amplitude. The fundamental, second harmonic, and third harmonic components of this modulation frequency in the light output of the laser are used to control the tilt angles of the mirrors, the RF-excitation power input, and the separation of the mirrors, respectively. The frequency stability is determined by observing the photobeat between the outputs of two independently stabilized lasers. Isotopically enriched samples of Ne are used in the two lasers with one of them enriched in Ne-20 and the other in Ne-22. The optical output of a laser stabilized in this manner is frequency modulated, and the center frequency has been found to be stable to several parts in  $10^{10}$  over very long periods. (Author) D. H.

#### A65-21624

##### SELF-INDUCED OSCILLATIONS IN THE STIMULATED LIGHT EMISSION FROM GaAs INJECTION LASERS.

R. S. Levitt and M. H. Pilkuhn (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N.Y.).

Journal of Applied Physics, vol. 36, Mar. 1965, p. 859. 5 refs.



## A65-21625

Occurrence of self-induced oscillations in the output of a Fabry-Perot-type GaAs injection laser operated with long current pulses at a current considerably above the lasing threshold. Such oscillations appear rather suddenly at a particular current which is usually 1.5 to 2.2 times the threshold current at 77°K. Upon further increase in current, the amplitude of the oscillations decreases again until they disappear completely. The frequency of the oscillations was found to vary with temperature; cooling the liquid nitrogen bath from 77°K to 63°K resulted in a frequency change from 6 to 8 Mc. It was difficult to induce oscillations at liquid helium temperatures, but 0.8 Mc oscillations at 8410 Å were induced in one diode when the current density reached 3.5 times threshold. The shape and amplitude of the oscillations were found to depend on environment; oscillations could not be induced in vacuum at slightly above 77°K but were observed in liquid nitrogen and in liquid oxygen (90°K). It is suggested that local current or temperature instabilities occurring at certain critical current densities might be responsible for the effect. D.H.

## A65-21623

### STIMULATED EMISSION IN AN EUROPIUM CHELATE SOLUTION AT ROOM TEMPERATURE.

Erhard J. Schimitschek, John A. Trias, and Richard B. Nehrlich, Jr. (U.S. Navy, Electronics Laboratory, San Diego, Calif.). *Journal of Applied Physics*, vol. 36, Mar. 1965, p. 867, 868. 6 refs.

Determination of the effect of temperature and concentration on threshold pump energy when laser action is obtained in a europium chelate of the composition  $\text{Eu}(\text{BTF})_3 \cdot \text{H}_2\text{Pyrr}$ . (BTF stands for benzoyltrifluoroacetone and Pyrr stands for pyrrolidine). Solutions of this material in acetonitrile were transferred into a capillary laser cell, placed inside an elliptical laser head, and tested for stimulated emission. Spiking, line narrowing, and beam collimation were noted; the laser wavelength (6118 Å) showed no apparent dependency on concentration or temperature. Threshold energy decreased with both decreasing temperature (due to reduced fluorescence linewidth, higher quantum efficiency, and better optical quality) and decreasing concentration. The minimum concentration necessary for laser action was  $1.5 \times 10^{-3}$  moles/liter. The work of Winston et al. with a similar Eu-chelate solution is described briefly. D.H.

## A65-21626

### POWER SENSITIVE OPTICAL SWITCH FOR THE CONTROL OF HIGH BRIGHTNESS LASER PULSES.

Richard G. Tomlinson (Ohio State University, Dept. of Electrical Engineering, Antenna Laboratory, Columbus, Ohio). *Journal of Applied Physics*, vol. 36, Mar. 1965, p. 868-870. Contract No. AF 33(657)-10824.

Description of an optical switch which operates directly on the laser pulse by abruptly cutting it off when a selected power level is reached. The laser beam is brought to a focus by one lens and recollimated by a second; a high power density is created at the focal region immersed in a gas or a liquid, argon being used in the described experiments because of its flat breakdown characteristics. For each particular case of gas composition and pressure there exists a breakdown threshold. If the maximum power density in the focal region is below this threshold value, the laser pulse passes through the system with negligible attenuation; otherwise, a dense and turbulent plasma and a shock wave are generated which severely attenuate any further laser energy entering the system until recombination and diffusion have dissipated the plasma. With proper design, the optical switch can be constructed so as to produce little degradation of the spatial coherence of the laser beam and, thus, can be incorporated inside the laser cavity as a self-repairing optical fuse to protect laser components from damage. D.H.

## A65-21627

### CONTINUOUS ROOM-TEMPERATURE $\text{Nd}^{3+}$ : $\text{CaMoO}_4$ LASER.

R. C. Duncan (Radio Corporation of America, RCA Laboratories, Princeton, N. J.). *Journal of Applied Physics*, vol. 36, Mar. 1965, p. 874, 875. 8 refs. Research sponsored by the Radio Corporation of America; Contract No. AF 33(615)-1096.

Continuous laser action observed in  $\text{NdNbO}_4$ : $\text{CaMoO}_4$  crystals at 77°K and at room temperature. The crystals, about 1 in. long and 3/32 in. in diam. and of good optical quality, were grown by the

Czochralski technique by Brixner at Dupont. The strongest fluorescent lines, lying in the 1.07- $\mu$  region, are due to  $^4\text{F}_{3/2}$ -to- $^4\text{I}_{11/2}$  transitions. Laser tests were conducted in the center of a helical GE FT-524 flash lamp and also (in both pulsed and CW modes) at the focus of a system using an E.G. and G. FX-33 flash lamp and an AH-6 Hg lamp with a spherical mirror. The quasi-continuous and CW thresholds for the 1.067- $\mu$  line at 77°K were 530 and 850 watts, respectively. It is not yet understood why the 1.061- $\mu$  and the lower threshold 1.067- $\mu$  transitions show simultaneous laser oscillations in pulsed but not in CW operation at 77°K. Considerably higher power than the present few milliwatts is expected when the output coupling and the  $\text{Nd}^{3+}$  concentration are optimized. D.H.

## A65-21654

### SINGLE-ATOM COHERENCE EFFECTS IN MEASUREMENT OF SPONTANEOUS EMISSION LINEWIDTHS IN A HIGH-GAIN Ne LASER.

David F. Hotz (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

*Applied Physics Letters*, vol. 6, Apr. 1, 1965, p. 130-132. 7 refs.

Description of the use of single-atom coherence effects for measuring the spontaneous-emission linewidths of amplifying laser transitions. These effects involve the mixing of discrete atomic states, with definite phase relations between the states. Observations are made on the variation in intensity of plane-polarized light transmitted through a high-gain 3.39- $\mu$  Ne laser amplifier, for which the Zeeman levels of the amplifying transition are mixed in a zero-field-level crossing. The spontaneous-emission linewidth is found to be  $44 \pm 4$  Mc. Resolutions on the order of several times  $10^6$  are possible with the techniques described. P.K.

## A65-21656

### OPTICAL RESONATOR EFFECTS ON THE POPULATION DISTRIBUTION IN He-Ne GAS LASERS DETERMINED FROM SIDE LIGHT MEASUREMENTS.

Armand L. Waksberg and Allan I. Carswell (RCA Victor Co., Ltd., Research Laboratories, Montreal, Canada).

*Applied Physics Letters*, vol. 6, Apr. 1, 1965, p. 137, 138.

Research supported by the Canadian Directorate of Industrial Research.

Description of a method for observing the direct effect of laser oscillations on the population distribution in the discharge of a gas laser. The method uses the radiation emitted through the side walls (the so-called "side-light") of the laser discharge tube. A phase-lock amplifier is used to correlate small changes in the side light intensity with the off-and-on switching of the laser beam. By scanning wide spectral ranges, the phase-lock technique can provide quantitative information about the various levels being affected by the laser mechanism. P.K.

## A65-21657

### THE EFFECT OF SPATIAL MODULATION OF PUMP LIGHT ON THE LONGITUDINAL-MODE SPECTRA OF RUBY LASERS.

V. Evtuhov (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

*Applied Physics Letters*, vol. 6, Apr. 1, 1965, p. 141, 142. 6 refs. Contract No. AF 33(657)-11650.

Study of the effect that partially shielding a ruby laser rod from the pump light has on the longitudinal mode spectra of the laser. Various portions of a 1-in.-long, 3-mm-diam. ruby rod were shielded with metal bands 1-mm to 4-mm long. The rod, with silver reflectors, was placed in an elliptical cavity and pumped with a linear xenon flash lamp. The output spectra, as observed with a Fabry-Perot interferometer for laser levels up to about 15% above threshold, are presented for various shielding-band arrangements. P.K.

## A65-21662

### EIGENSTATES OF POLARIZATION IN LASERS.

H. de Lang (Philips' Gloeilampenfabrieken, Philips Research Laboratories, Eindhoven, Netherlands).

*Philips Research Reports*, vol. 19, Oct. 1964, p. 429-440. 16 refs.

A description of the two eigenstates of polarization which occur repetitively in a multiple-pass interferometer containing anisotropic elements. In the absence of amplitude anisotropy, these two

eigenstates are orthogonal and have equal losses. Common amplitude anisotropies are linear polarizers, based on either linear dichroism or reflection anisotropy. For practical problems, representation with the aid of the Poincaré sphere is very useful, although the matrix representation gives a fully adequate description of the polarization phenomena and can be used for numerical calculations. The principles of eigenstates are illustrated by two examples, one concerning a planar laser in a weak longitudinal magnetic field and the other concerning the frequencies of a ring laser in a magnetic field, which is a very sensitive instrument for testing the reasoning that the path length is equally isotropic for the two oppositely traveling waves. D.P.F.

#### A65-21905 \*

POLARIZATION OF LASER RADIATION [POLARIZATSIYA IZLUCHENIYA LAZERA].

A. M. Ratner.

*Optika i Spektroskopiya*, vol. 18, Feb. 1965, p. 258-266. 7 refs. In Russian.

Analysis of two laser radiation components polarized in mutually perpendicular directions. Assuming that one component is dominant, relations are derived linking the intensity with the dipole moment anisotropy and the pumping power. Resonators with plane and spherical reflectors are considered. The angular and spectral-energy distributions of the weaker component are found. W.M.R.

#### A65-21810 \*

PROPERTIES OF GAS LASERS CONTAINING OXYGEN/NOBLE-GAS MIXTURES [O NEKOTORYKH OSOBENNOSTIYAKH GAZOVYKH KVANTOVYKH GENERATOROV NA SMESIYAKH KISLORODA S BLAGORODNYMI GAZAMI].

S. G. Rautian and P. L. Rubin.

*Optika i Spektroskopiya*, vol. 18, Feb. 1965, p. 326-328. 9 refs. In Russian.

Theoretical examination of  $O_2 + Ne$  and  $O_2 + Ar$  laser operation under excitation of the level  $OI3^3P$  through collision-induced dissociation of oxygen. The spontaneous-emission components corresponding to the fine structure of the transitions  $3^3P_2, 1, 0 - 3^3S_1$  have been found to have an anomalously large bandwidth ( $3 \times 10^9$  cps); the radiation bandwidth is at least an order lower, while the Doppler width, calculated for a Maxwellian velocity distribution at  $T = 370^\circ K$ , is only  $1.2 \times 10^9$  cps. In the case of  $3^3P_2 - 3^3S_1$ , the oscillation frequency is found to be shifted (by  $2 \times 10^9$  cps) with respect to the maximum of the spontaneous emission, while, in spite of the fact that amplification at  $3^3P_1 - 3^3S_1$  is above threshold, no oscillation on this transition is observed. These peculiarities are explained by a non-Maxwellian recalculation of the excited-atom distribution with inclusion of a translational energy contribution that is substantially greater than  $kT$ . W.M.R.

#### A65-21811 \*

SPECTROSCOPIC APPLICATIONS OF GAS LASERS [SPEKTROSKOPICHESKIE PRIMENENIYA GAZOVYKH KVANTOVYKH GENERATOROV].

G. G. Petrushin and S. G. Rautian.

*Optika i Spektroskopiya*, vol. 18, Feb. 1965, p. 336, 337. In Russian.

Proposed method for calculating the probabilities of spontaneous transitions  $m \rightarrow j, n \rightarrow k$ , from the flux ratio  $\Phi_{mj}/\Phi_{nk}$  at oscillation cutoff. Ordinary spectroscopic methods can provide the product  $A_{mn} [N_m - (g_m/g_n) N_n]$ . At sufficient discharge intensity or gas pressure, the oscillations cease, the populations of the upper levels tend to equalize, and the ratio  $N_m/N_n$  approaches unity. Considering this, formulas are derived for calculating  $A_{mn}$  and the ratio  $A_{mj}/A_{nk}$ . It is shown how the absolute magnitudes of these probabilities may also be found. W.M.R.

#### A65-21873

STABILITY CONSIDERATIONS FOR A  $Rb^{87}$  MASER OSCILLATOR.

P. Davidovits and R. Novick (Columbia University, Columbia Radiation Laboratory, New York, N. Y.).

(Institute of Electrical and Electronics Engineers, International Convention, New York, N. Y., Mar. 22-26, 1965.)

IEEE International Convention Record, vol. 13, pt. 5, 1965, p. 2-6. 10 refs.

Contract No. DA-36-039-SC-90789.

Discussion of self-sustained oscillation obtained in an optically pumped rubidium maser operating at the  $Rb^{87}$  hyperfine transition frequency of 6835 Mc. The entire apparatus can be mounted within the volume of one cu ft. The operating temperature is  $60^\circ C$ , and the overall power consumption is only a few watts. The anticipated long-term stability is one part in  $10^{12}$ . Preliminary estimates also indicate that the device has far better short-term stability than any other existing frequency standard. The basic principles of the rubidium maser are explained, and the factors affecting the stability of oscillation are examined. (Author) M.M.

#### A65-21875

PIEZOELECTRIC DETECTION OF LASER PULSES WITH CADMIUM SULPHIDE THIN FILMS.

M. S. Bruma and M. F. Velghe (Centre National de la Recherche Scientifique, Bellevue, Seine-et-Oise, France).

(Institute of Electrical and Electronics Engineers, International Convention, New York, N. Y., Mar. 22-26, 1965.)

IEEE International Convention Record, vol. 13, pt. 5, 1965, p. 17-20. 17 refs.

Consideration of the possibility of processing evaporated CdS thin films to act as piezoelectric transducers for detecting laser-induced elastic vibrations. High sensitivity, fast, piezoelectric response of CdS thin films is demonstrated by the detection of elastic vibrations induced in air by an unfocused ruby laser beam, suggesting applications to pulse laser demodulation techniques. (Author) M.M.

#### A65-21876

FM LASER OSCILLATION - THEORY AND EXPERIMENT.

S. E. Harris, O. P. McDuff (Stanford University, Dept. of Electrical Engineering, Stanford, Calif.), and Russell Targ (Sylvania Electric Products, Inc., Sylvania Electronic Systems Div., Electronic Defense Laboratories, Mountain View, Calif.). (Institute of Electrical and Electronics Engineers, International Convention, New York, N. Y., Mar. 22-26, 1965.)

IEEE International Convention Record, vol. 13, pt. 5, 1965, p. 21-26. 12 refs.

Contracts No. AF 33(657)-11144; No. AF 33(615)-1938.

Consideration of a type of laser oscillation wherein the laser modes oscillate with approximately FM phases and nearly Bessel function amplitudes, and thereby comprise the sidebands of a frequency-modulated light signal. This type of FM oscillation is induced by an intracavity phase perturbation which is driven at a frequency which is approximately, but not exactly, that of the axial mode spacing. The resulting laser oscillation frequency may, in effect, be swept over the entire Doppler linewidth. A first-order theory, some experimental results, and an interesting application are considered. (Author) M.M.

#### A65-21951

THE DARK SIDE OF THE LASER.

J.J. Schlickman and R.H. Kingston (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).

Electronics, vol. 38, Apr. 19, 1965, p. 93-98. 7 refs.

Description of a dosimeter that measures the energy of a reflected laser pulse, developed as a safeguard against eye damage. Readings of the dosimeter will tell when the radiation has reached the danger level. Data obtained from experiments on eye damage in rabbits were used to develop and calibrate the laser dosimeter. The device is named pulsed laser dosimeter because it measures the total energy exposure per laser pulse and utilizes a modified gamma-radiation dosimeter as a high-impedance voltmeter. In addition, the observer is provided with an absolute means of determining the radiation dosage, since the calibrated scale is a linear function of energy density. The instrument's dynamic range encompasses all the known normal mode lasers operating within the S-1 spectral response ( $6,000$  to  $10,000 \text{ \AA}$ ) of the detector. Provisions have not been made, however, for work with Q-spooled lasers, which produce pulses having a rise time of  $0.5$  to  $1$  nanosecond, and a duration of only a few nanoseconds. This is said to be due to design difficulties and to a lack of quantitative data about such lasers. M.M.

## A65-21954

### A65-21954

#### LIGHT ON THE LASER'S FUTURE.

T.H. Mairman (Korad Corp., Santa Monica, Calif.).  
*Electronics*, vol. 38, Apr. 19, 1965, p. 119-121.

Discussion of the future possibilities and practical applications of the laser. The subjects considered are: (1) theory and practice, (2) optically pumped solids, (3) semiconductor lasers, (4) ancillary equipment, and (5) future applications.

M. M.

### A65-22206

#### GAS-PHASE LASER AS A SOURCE OF LIGHT FOR AN OPTICAL DIFFRACTOMETER.

G. Harburn, K. Walkley, and C. A. Taylor (Manchester College of Science and Technology, Physics Dept., Manchester, England).  
*Nature*, vol. 205, Mar. 13, 1965, p. 1095, 1096.

Description of the use of continuous-output gas-phase lasers as small-bandwidth sources of light for optical diffractometers. The improvement in resolution that an He-Ne laser offers over the usual combination of mercury-vapor lamp and interference filter is described. By focusing the output of the laser on the pinhole of the diffractometer, the necessary brightness is easily obtained with an extremely small bandwidth. For laser outputs of about 3 mw, photographic exposures can be obtained which are comparable to those for a 250-watt compact-source mercury-vapor lamp in conjunction with a 70-Å bandwidth interference filter.

P. K.

### A65-22463

#### INFRARED EMISSION OF CO AND CO<sub>2</sub>, AND A CONTINUOUS CO<sub>2</sub> LASER BY DIRECT ACTION OF A HIGH-FREQUENCY EXCITATION [EMISSION INFRAROUGE DE CO ET CO<sub>2</sub> ET LASER CONTINUU A CO<sub>2</sub> PAR ACTION DIRECTE D'UNE EXCITATION HAUTE FREQUENCE].

Pierre Barchewitz, Lucien Dorbec, Robert Farrenq, Alain Truffert, and Philippe Vautier (Paris, Université, Laboratoire d'Infrarouge, Chimie Physique, Orsay, Seine-et-Oise; Société Anonyme des Télécommunications, Laboratoire de Physique, Paris, France).

*Académie des Sciences (Paris), Comptes Rendus*, vol. 260, no. 13, Mar. 29, 1965, p. 3581, 3582. In French.

Study of the vibrational emission of CO and CO<sub>2</sub> toward 4.5 μ, produced by direct high-frequency excitation of pure or mixed gases, with discussion of its application to the production of a continuous CO<sub>2</sub> laser emission towards 10.5 μ (vibrational transition 00<sup>0</sup>1 - 10<sup>0</sup>0) of lines of the branch P, the most intense of which is the P(20) line. The laser has a power of the order of 0.1 watt.

F. R. L.

### A65-22501 \*

#### APPLICATIONS OF A GAS LASER TO AERODYNAMIC TESTING.

Koichi Oshima, Masao Yamamoto, Katsutaka Sugaya, and Yuko Oshima.

Tokyo, University, Institute of Space and Aeronautical Science.  
*Bulletin*, vol. 1, Jan. 1965, p. 1-27. In Japanese.

Description of the highly successful application of a He-Ne gas laser to conventional schlieren methods and Mach-Zehnder interferometry. The high brightness of the laser light source permits such sensitive schlieren photography that the maximum sensitivity obtained is actually limited by diffraction of the laser light beam due to the models. The high monochromaticity and brightness make adjustments of Mach-Zehnder interferometers very easy, and high quality interferograms can be obtained for fields with very large optical path differences (millions of fringe shifts). Such high interferency of the laser light in Mach-Zehnder interferometry suggests several new applications, such as measurement of temperature fields in transparent liquids or solids, and strain analyses of solid models. A few other laser applications to gasdynamic testing are proposed, including heterodyne detection of two laser light beams in order to analyze the interference between light waves and plasmas.

(Author) D. H.

### A65-22614

#### EYE PROTECTION AGAINST LASERS.

C. H. Swope and C. J. Koester (American Optical Co., Southbridge, Mass.).

(Optical Society of America, Spring Meeting, Washington, D.C., Apr. 1964.)

*Applied Optics*, vol. 4, May 1965, p. 523-526. 6 refs.

Calculations from published data on threshold dosage for an observable retinal lesion to determine the attenuation required to protect the human eye against pulsed laser radiation. Several highly attenuating filters were evaluated in terms of the maximum laser energy against which they provide protection. Because of their very high absorption, some of the filters were found to break or craze at relatively low energies. A solution to this problem which provides eye protection against an Nd-doped glass laser delivering up to 740 J in an impact area 5 mm in diameter on the filter is described. Several suggestions are made for protecting the eyes of personnel working with lasers.

(Author) F. R. L.

### A65-22615

#### GAIN NARROWING IN A LASER AMPLIFIER.

David F. Hotz (Fresno State College, Dept. of Physics, Fresno, Calif.).

*Applied Optics*, vol. 4, May 1965, p. 527-530.

Observation of the phenomenon of gain narrowing of an inhomogeneously broadened line in stimulated emission. Good agreement with theory was found. The effect was observed by measuring the variation in gain across the amplifying line using a fixed frequency laser oscillator and a tunable single-pass laser amplifier.

(Author) F. R. L.

### A65-22616

#### LASER EMISSION LINES AND MATERIALS.

Albert J. Bevo (Washington University, Dept. of Physics, St. Louis, Mo.) and William A. Barker (Santa Clara, University, Dept. of Physics, Santa Clara, Calif.).

*Applied Optics*, vol. 4, May 1965, p. 531-543. 92 refs.

Display of data on many of the laser materials reported in the literature up to May 1964. The first section contains a list of laser emission lines arranged according to increasing wavelength along with the corresponding active ion and host material. The second section contains information on parameters pertinent to laser performance. In both sections each line is referenced. No attempt has been made to include the wavelengths generated by second harmonics or the Raman effect. In this tabulation the total number of laser lines considered is 357. These lines originate from 65 laser systems. This catalog is intended to be of special use to research workers in the life sciences who may not be familiar with the range of laser frequencies now available.

(Author) F. R. L.

### A65-22619

#### THE OPERATIONAL CHARACTERISTICS OF A CW Nd:CaWO<sub>4</sub> LASER IN THE RANGE OF DRY ICE TO ROOM TEMPERATURE.

H. R. Aldag, R. S. Horwath (Sperry Rand Corp., Sperry Gyroscope Co., Electro-Optics Group, Great Neck, N.Y.), and C. B. Zarowin (Laser, Inc., Briarcliff Manor, N.Y.).

(Optical Society of America, Spring Meeting, Washington, D.C., Apr. 1964.)

*Applied Optics*, vol. 4, May 1965, p. 559-563.

USAF-supported research.

Discussion of the operational characteristics of a continuous-wave Nd:CaWO<sub>4</sub> laser in the range of dry ice to room temperature. The experimental results are compared with the predicted equations for power output and threshold power. It has been found that output power is a linear function of absorbed pump power as predicted from the rate equations for a four-level laser medium. The threshold equation agrees qualitatively with the experimental results in that it decreases with decreasing temperature due to the consequent narrowing of the fluorescent line-width. The threshold condition has been used to indicate the quantities that must be monitored to optimize the crystal preparation and growth conditions. Continuous-wave operation has been obtained with an ac and dc pump lamp.

(Author) F. R. L.

### A65-22620

#### GAS MIXTURES AND PRESSURES FOR OPTIMUM OUTPUT POWER OF RF-EXCITED HELIUM-NEON GAS LASERS AT 632.8 NM.

Klaus D. Mielens and Karl F. Nefflen (National Bureau of Standards, Washington, D.C.).

Applied Optics, vol. 4, May 1965, p. 565-567.

Experimental establishment of conditions for optimum laser action. Two laser discharge tubes, of 50-cm length and 3-mm and 5-mm i.d., respectively, were filled with three different mixtures of helium and neon at varying total pressures. The gas fillings for which the two tubes yielded optimum action under rf excitation in a 60-cm confocal cavity at 632.8 nm were a 7:1 gas mixture at 2.3 torr for the 3-mm tube, and a 9:1 mixture at 2.0 torr for the 5-mm tube. The 3-mm tube was found to be superior in peak output power and ease of adjustment of the laser. (Author) F.R.L.

#### A65-22621

CHARACTERISTICS OF A SIMPLE SINGLE-MODE He-Ne LASER. K. M. Baird, D. S. Smith, G. R. Hanes (National Research Council, Div. of Applied Physics, Ottawa, Canada), and S. Tsunekane (Government Mechanical Laboratory, Tokyo, Japan).

Applied Optics, vol. 4, May 1965, p. 569-571.

Development of a simple laser system which is useful in metrological applications. The emission is a single frequency at 0.63  $\mu$ , stable to the order of five parts in  $10^8$ . The output is about 50  $\mu$ w, sufficient for most interferometric metrology. (Author) F.R.L.

#### A65-22622

VISIBLE AND UV LASER OSCILLATION AT 118 WAVELENGTHS IN IONIZED NEON, ARGON, KRYPTON, XENON, OXYGEN, AND OTHER GASES.

William B. Bridges and Arthur N. Chester (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

Applied Optics, vol. 4, May 1965, p. 573-580. 21 refs.

Observation of laser oscillation at one hundred and eighteen wavelengths in ionized neon, argon, krypton, xenon, oxygen, and other gases in the spectral range 2677 Å to 7993 Å. Of these lines, ninety-six have been definitely identified, and arise from singly, doubly, and triply ionized atoms. A 2-m, pulsed dc discharge was employed. Measured and calculated wavelengths and level classifications are tabulated. The majority of the laser lines observed are shown by comparison with calculated relative line strengths to be the strong lines predicted by L-S coupling that possess lower levels optically connected to the ion ground state. The rules  $\Delta S = 0$ ,  $\Delta J = \Delta L = +1$  are reasonably well obeyed, although violations of L-S restrictions on core change and multiplicity are also observed. Evidence of upper level population by electron collision with ground-state ions is presented. The time dependence of laser output under pulsed excitation is discussed. (Author) F.R.L.

#### A65-22624

INTERDEPENDENCE OF THRESHOLD, FILAMENT POSITION, AND EFFICIENCY IN A LINEARLY PUMPED RUBY ROD.

Eugene W. Sucov (Westinghouse Electric Corp., Research Laboratories, Pittsburgh, Pa.).

Applied Optics, vol. 4, May 1965, p. 593-596. 8 refs.

Use of a ruby laser rod to map the distribution of light intensity generated by a flash lamp inside a cylindrical reflecting cavity. A fairly sharp focal region is found, but not at the expected location. The location of the real focal region, which is identified by minimum threshold and central lasing spot, is controlled by small changes in geometry. Energy conversion efficiency increases by about 40% when a laser rod is placed such that its center is coincident with the real focal region. A simple model is proposed to explain the motion of the lasing filament within the rod as the rod itself is moved within the sharply focused radiation field. A detailed test of this model shows good agreement with measurements. (Author) F.R.L.

#### A65-22625

IMMERSION LIQUIDS FOR RUBY LASERS.

M. E. Graham, B. I. Davis, and D. V. Keller (Northrop Corp., Ventura Div., Newbury Park, Calif.).

Applied Optics, vol. 4, May 1965, p. 613-615. 6 refs.

Results of a search for high index of refraction liquids suitable for immersion of ruby crystals in high-energy lasers. One liquid,  $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$  in glycerin, is reported which can exactly match the index of ruby (1.76) and which, at the same time, is stable to the flash-lamp environment and transparent at the ruby pumping and lasing wavelengths. Another liquid, saturated aqueous  $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$ , has a slightly lower index (1.60), but is more generally useful because of its low viscosity. Eight additional liquids with indices in the range from 1.43 to 1.54 are reported, and tables are included which list the relevant properties of all of the liquids considered.

(Author) F.R.L.

#### A65-22626

A COMPACT PULSED GAS LASER FOR THE FAR INFRARED.

L. N. Large and H. Hill (Services Electronics Research Laboratory, Baldock, Herts., England).

Applied Optics, vol. 4, May 1965, p. 625, 626.

Description of a compact sealed-off laser based on a 4.8-m tube as a convenient source of stimulated emission in the far IR. The source was designed to operate at 27.9  $\mu$  to take advantage of the strong oscillation obtained from the pulsed water vapor discharge at this wavelength. After operation of one of these lasers for 30 hr at 100-cps repetition rate, corresponding to 300 hr at 10 cps, the peak output power was unchanged from that initially measured.

F.R.L.

#### A65-22627

DETERMINATION OF ELECTRON-BEAM PENETRATION IN LASER CRYSTALS.

M. Stimler (U.S. Naval Ordnance Laboratory, Silver Spring, Md.).

Applied Optics, vol. 4, May 1965, p. 626-628.

Use of a curve based on data presented by Ehrenberg and King to determine the penetration depth for 20-keV electrons into materials of known density. Analysis was also performed to extend the usefulness of the curve to cover a range of electron energies from 10 keV to 90 keV.

F.R.L.

#### A65-22728

PULSED LASER ACTION IN MOLECULAR HYDROGEN.

P. A. Bashulin, I. N. Kniazev, and G. G. Petraash (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 47, Oct. 1964, p. 1590, 1591.)

Soviet Physics - JETP, vol. 20, Apr. 1965, p. 1068, 1069. Translation.

#### A65-22785

NEAR-INFRARED OSCILLATION IN PULSED NOBLE-GAS-ION LASERS.

Douglas C. Sinclair (U.S. Army, Engineer Research and Development Laboratories, Fort Belvoir, Va.).

#### A65-22932

MODES IN SPHERICAL-MIRROR RESONATORS.

Walter A. Specht, Jr. (California Institute of Technology, Div. of Engineering and Applied Science, Pasadena, Calif.).

Journal of Applied Physics, vol. 36, Apr. 1965, p. 1306-1313. 35 refs.

Contract No. AF 49(638)-1322.

Examination of a cavity-mode approach to the mode structure of a laser. Solutions of the vector wave equation for electromagnetic fields in and between perfectly conducting oblate spheroidal cavities are examined for the case of wavelengths much less than cavity dimensions. These solutions are the field modes in Fabry-Pérot type resonators with equal-radius concave spherical mirrors, or with concave-convex spherical mirrors, when the parameters of the oblate spheroids are chosen so that the radii of curvature and spacing on the axis of rotation match those of the resonator mirrors. Expressions for the transverse and longitudinal mode structures are derived. The eigenvalue equations are written and solved for the case of the two lowest-order modes. (Author) A.B.K.

## A65-22933

### A65-22933

#### COMPLETE SOLUTIONS TO THE RATE EQUATIONS DESCRIBING Q-SPOILED AND PTM LASER OPERATION.

R. B. Kay and G. S. Waldman (McDonnell Aircraft Corp., St. Louis, Mo.).

*Journal of Applied Physics*, vol. 36, Apr. 1965, p. 1319-1323.

7 refs.

Derivation of the solutions of the rate equations describing the Q-spoiled and pulsed-transmission-mode (PTM) operation of a three-level laser. These solutions were carried out in two time regions: (1) the delay time followed by (2) the pulse time. Region (1) was tractable with approximate analytic methods, while in region (2) the equations were solved by analog computer. The effect of the duration of the Q switch on the delay time and on the PTM operation is investigated. It is found that Q-switch times as long as 20 nsec give satisfactory PTM operation. (Author) A. B. K.

### A65-22949 \*

#### THE LASER AS A LIGHT SOURCE FOR THE MACH-ZEHNDER INTERFEROMETER.

R. A. Jackson (Royal College of Advanced Technology, Dept. of Mechanical Engineering, Salford, Lancs., England).

*Journal of Scientific Instruments*, vol. 42, Apr. 1965, p. 282, 283.

Use of gas laser as a light source for a Mach-Zehnder interferometer. The operation of this system is compared with the familiar arrangement employing a mercury vapor lamp. High contrast fringes are demonstrated, and it is further shown that the interferometer adjustments may be simplified when a laser is used. (Author) M. M.

### A65-23004 \*

#### CALCULATION OF A MASER SINGLE PULSE IN THE COURSE OF INSTANTANEOUS SWITCHING OF AN INTERFEROMETER [RASCHET MONOIMPUL'SA KVANTOVOGO GENERATORA PRI MGNOVENNOM VKLUCHENII INTERFEROMETRA].

A. M. Samson and V. A. Savva (Akademiia Nauk Belorusskoi SSR, Institut Fiziki, Minsk, Belorussian SSR).

*Akademiia Nauk BSSR, Doklady*, vol. 9, Jan. 1965, p. 22-26.

8 refs. In Russian.

Derivation of formulas which make it possible to analyze the basic characteristics of a peak pulse generated by a maser, when the loss factor is rapidly decreased by switching an interferometer. The pulse characteristics are obtained as a function of the population inversion, pumping power, mirror reflectivity, the interferometer base, and other parameters of the substance and resonant cavity.

V. P.

### A65-23014

#### TIME DEPENDENCE OF STIMULATED EMISSION IN A RUBY LASER WITH SPHERICAL MIRRORS.

T. N. Zubarev and A. K. Sokolov.

*(Akademiia Nauk SSSR, Doklady*, vol. 159, Nov. 21, 1964, p. 539.)

*Soviet Physics - Doklady*, vol. 9, May 1965, p. 1006, 1007.

Translation.

Study of the time course of stimulated emission in a 12- x 120-mm ruby rod coaxial with an optical cavity employing opaque Al-coated spherical mirrors with radii of curvature of ~ 400 mm. Modulation was by means of a helical Xe flash tube supplying 7.5 kJoules of energy in flashes of 1 msec duration. The intensity measurements were performed at room temperature. At sufficiently high pumping power (capacitor voltage  $U = 5$  kv), laser action began with a transitional period of damped oscillation, followed by a quasi-static regime involving a constant (more precisely, a smoothly varying) component with a modulation depth of 10 to 20%. At relatively low pumping power ( $U = 2.5$  to 4 kv), the emission was in the form of a regular sequence of undamped pulses with practically no constant component. The effect of varying the distance between mirrors was investigated. W. M. R.

### A65-23155

#### A BROADBAND SOLID-STATE MICROWAVE MASER OPERATION AT 77.4°K.

E. O. Ammann (Sylvania Electric Products, Inc., Sylvania Electronic Systems Div., Electronic Defense Laboratories, Mountain View, Calif.).

*IEEE Transactions on Microwave Theory and Techniques*, vol.

MTT-13, Mar. 1965, p. 186-193, 36 refs.

Contract No. DA-36-039-SC-90839.

Study of several aspects of the problem of obtaining solid-state microwave maser action at 77.4°K. A maser cavity, designed to have a large filling factor, high unloaded Q, and tunability over a 2% range is described. Using this cavity, a study was made of ruby as a maser material at 77.4°K. An important result of this study is the determination of the optimum Cr+++ concentration for 77.4°K maser action. A well-known broadbanding technique was applied to the maser to increase its gain-bandwidth product. Two high-Q microwave cavities spaced 3/4 wavelength apart were placed in front of the maser cavity to produce the broadbanding. The experimental results are given, and the usefulness of this technique as a method of improving maser performance is evaluated. The broadbanded maser had a midband gain of 14.5 db and a bandwidth of 7.5 Mc at a signal frequency of 9.3 Gc. Approximately 3-1/2 watts of pump power at 23.4 Gc were required. (Author) D. H.

### A65-23196

#### SYSTEMS PROBLEMS IN THE USE OF LASERS IN SPACE COMMUNICATION.

E. B. Moss (Douglas Aircraft Co., Inc., Missile and Space Systems Div., Santa Monica, Calif.).

IN: ELECTRONICS IN TRANSITION; WINTER CONVENTION ON MILITARY ELECTRONICS, 6TH, LOS ANGELES, CALIF., FEBRUARY 3-5, 1965, PROCEEDINGS. VOLUME 4. [A65-23182 13-09]

Conference sponsored by the Professional Technical Group on Military Electronics of the Institute of Electrical and Electronics Engineers, Los Angeles Section.

Los Angeles, Institute of Electrical and Electronics Engineers, Los Angeles District, 1965, p. IIB-26 to IIB-39, 17 refs.

Examination of problems involved in the use of lasers in space communication. The relative merits of microwave and optical systems are analyzed. The problem of coherence is discussed in its connection with narrow beam formation and with the possibility of frequency modulation of the carrier. Problems connected with the receiver optics and beam deflection are considered. Tracking, beam pointing, and acquisition are studied in some detail. Various atmospheric effects are taken into account. It is concluded that the application of the laser to space communication awaits further advances primarily in the field of laser technology. Until such advances are made, it is said that optical communication cannot replace uhf, since the reliability of a microbeam optical link is too low for total reliance to be placed on it. The ultimate role of optical communication in space is seen to be as a medium for the mass transfer of qualitative information rather than as a substitute for conventional telemetry. A. B. K.

### A65-23273

#### A CONTINUOUS N<sub>2</sub>O LASER BY THE DIRECT ACTION OF HIGH-FREQUENCY EXCITATION [LASER CONTINU A N<sub>2</sub>O PAR ACTION DIRECTE D'UNE EXCITATION HAUTE FREQUENCE].

Pierre Barchewitz, Lucien Dorbec, Alain Truffert, and Philippe Vautier (Paris, Universite', Laboratoire d'Infrarouge, Orsay, Seine-et-Oise; Société Anonyme de Télécommunications, Laboratoires de Physique, Paris, France).

*Académie des Sciences (Paris), Comptes Rendus*, vol. 260,

no. 15, Apr. 12, 1965, p. 4179-4181. In French.

Experimental data on laser action observed by the direct hf excitation of N<sub>2</sub>O and a N<sub>2</sub>O-argon mixture placed in a laser cavity. The intensity of the emission of direct hf-excited N<sub>2</sub>O was lower than that observed for pure CO<sub>2</sub>; the emission obtained with an N<sub>2</sub>O-argon mixture was of low intensity and unstable in character. The exciting frequency was approximately 20 Mc, and the rays were of the Branch P type, which corresponds to a vibrational transition of 00<sup>0</sup><sub>1</sub>-10<sup>0</sup><sub>0</sub>; these rays are substantially the same as those observed by Patel. Thus it would appear that an energy exchange due to resonating collisions plays a basic role in the observed laser emission. The laser cavity was 1.20 m long, corresponding to a spacing of 125 Mc between the longitudinal modes of agreement. D. P. F.

**A65-23385 #****MEASUREMENT OF THE CHROMIUM-DOPED RUTILE MASER OPERATING AT THE LIQUID NITROGEN TEMPERATURE.**

Risao Hayashi and Takashi Igarashi (Ministry of Post and Telecommunications, Radio Research Laboratories, Tokyo, Japan). Radio Research Laboratories, Journal, vol. 12, Jan. 1965, p. 53-58. 5 refs.

Experimental investigation of a chromium-doped rutile maser operating at the liquid nitrogen temperature. The profile of the inversion ratio was measured with various concentrations of chromium in rutile. Applying the effect of cross relaxation, as the result of observations, an inversion ratio of about 2 was obtained. At this temperature, it was found that the maser action is possible, and the cross relaxation effect was observed in the rutile maser investigated. (Author) M.M.

**A65-23384****TOWARDS A LASER RADAR FOR NEAR-HORIZON USE.**

A. F. Nicholson (Philips Industries Pty., Ltd., Research Laboratory, Hendon, South Australia, Australia).

IEEE Transactions on Military Electronics, vol. MIL-9, Jan. 1965, p. 70-72.

Discussion of a laser radar that uses a wide-angle, flood-lighting but lopsided energy beam that is cut off sharply across a certain surface so that it can be used near the horizon or other interfaces with minimal terrain back reflections. It has a control system that moves the energy beam so as to avoid terrain reflections, and creates an effective control beam which is angularly wider than the energy beam so that targets outside the energy beam but in the control beam can be "followed" to an extent which is explained in detail. The system might be used for tracking objects close to the horizon, such as low-flying aircraft, and, later (if it were possible to lock on to the appropriate Doppler shifts) perhaps even below and short of the horizon. It might be possible to develop a beamriding missile based on the same ideas for use against targets close to the horizon or, if the beam were laid by a human operator, against low-speed targets below the horizon. (Author) V.P.

**A65-23619 #****MISSILE ATTITUDE SENSING WITH POLARIZED LASER BEAMS.**

John L. Dailey (Radio Corporation of America, Defense Electronic Products, Missile and Surface Radar Div., Moorestown, N.J.).

IN: NEW DIMENSIONS IN SPACE TECHNOLOGY; SPACE CONGRESS, 2ND, COCOA BEACH, FLA., APRIL 5-7, 1965, PROCEEDINGS. [A65-23599 13-31]

Congress sponsored by the Canaveral Council of Technical Societies. Cocoa Beach, Canaveral Council of Technical Societies, 1965, p. 281-298.

Design of an optical system to monitor the attitude of a missile during early launch phase. The system utilizes passive reflective components mounted on the missile to return a pair of laser beams transmitted from a ground station. The beams have their polarization state modulated by the reflective elements such that polarization is a function of missile attitude. The returned beams are passed through a polarization analyzing system at the ground station and missile attitude computed from the measured polarization parameters. (Author) D.H.

**A65-23626 #****APPLICATION OF THE LASER TO ELECTRIC PROPULSION.**

F. A. Giori and A. S. Gilmour, Jr. (Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.).

IN: NEW DIMENSIONS IN SPACE TECHNOLOGY; SPACE CONGRESS, 2ND, COCOA BEACH, FLA., APRIL 5-7, 1965, PROCEEDINGS. [A65-23599 13-31]

Congress sponsored by the Canaveral Council of Technical Societies. Cocoa Beach, Canaveral Council of Technical Societies, 1965, p. 386-402.

Research supported by Cornell Aeronautical Laboratory.

Use of focused light from a ruby laser to produce ion currents of several amperes and electron currents of hundreds of amperes from a surface disk less than 0.020 in. in diam. Ion velocities have been measured to be over 4 km/sec as emitted; they changed very slowly with changes in laser energy applied to the emitter. Estimates of emitter temperature and plasma density together with

electrical measurements of currents and voltages indicate a highly ionized plasma. Mass spectrometer measurements verified that only singly charged atoms were being formed and that ionization of the emitter was over 99% complete. These findings suggest that the laser-excited emission technique should find favorable application to two types of thrusters. In one type the impulse caused by the relatively high initial velocity of the emitted particles would be used directly; in the second, the high density relatively monoenergetic and highly ionized plasma would be used as an ion or plasma source in an accelerator type of thruster, thus obtaining higher ejection velocities and consequent higher values of specific impulse. The experimental results show that thrusts of about 25 millipounds were produced with 196 watts/millipound power consumption. The specific impulse in the direct thruster example cited was about 600 sec. When used as an ion source, several amperes of ion current can be obtained at ionization efficiencies of 600 ev/ion when only the laser is used. The energy required for ion production was found to be as low as 30 ev/ion when ionization was enhanced by the external circuit. Thrust and specific impulse in this case are controlled by the accelerating potentials selected for a given engine. (Author) D.H.

**A65-23846****A STUDY OF LASER CAVITIES USING THE GEOMETRICAL OPTICS APPROXIMATION [ETUDE DES CAVITES LASER DANS L'APPROXIMATION DE L'OPTIQUE GEOMETRIQUE].**

B. Macks (Centre National d'Etudes des Télécommunications, Issy-les-Moulineaux, Seine, France).

Journal de Physique, vol. 26, Mar. 1965, p. 104A-112A. 9 refs. In French.

A method for calculating optimum laser cavity structures using matrix calculations based on the geometrical optics approximation. The technique is first developed for classical two-mirror laser cavities and then extended to three-mirror resonators and ring cavities. While this method has been limited to three-mirror configurations, it can easily be extended to square or other four-sided loops which are of interest when using lasers as gyroscopes and as sensitive interferometers. Since the method is based on the optical-geometrical approximation, it gives no quantitative information on cavity losses; it also gives no data relative to polarization phenomena. However, the matrix calculations have the advantage of being flexible and of general application. D.P.F.

**A65-23847****THE LASER EFFECT AND ELECTROLUMINESCENCE IN GALLIUM ARSENIDE [EFFET LASER ET ELECTROLUMINESCENCE DANS LE GALLIUM ARSENIC].**

J. Fertin and J. Meuleman (Radiotechnique S.A., Laboratoire de Développement Physico-Chimique, Caen, France).

(Société Française de Physique, Groupes Optique, Spectroscopie et Physique du Solide, Meeting, Dijon, France, Apr. 30-May 2, 1964.)

Journal de Physique, vol. 26, Mar. 1965, p. 119A-121A. In French.

A summary of the physical conditions required to obtain the laser effect in a p-n junction, followed by a brief description of the technology used in constructing laser devices. Most of the semiconductors which fall under columns III and V of the periodic table are better emitters of light than silicon or germanium. The inversion of carrier population permits of obtaining the laser effect if two conditions are fulfilled: (1) that the quantity of energy of the stimulated emission be greater than that lost by absorption and diffraction; (2) that the structure be capable of resonating so as to confine the electromagnetic energy, thus obtaining coherence. The first of these two conditions is the most difficult to meet. Experimental techniques for the preparation of gallium arsenide crystals are described. When operating, the laser device must be cooled to the temperature of liquid nitrogen. Peak injected energy can vary between 50 and 200 watts, with a very weak form factor of  $10^{-3}$  to  $10^{-4}$ , so as to avoid raising the temperature. Temperature is critical. Switching properties are studied. D.P.F.

**A65-23964****DETECTORS FOR MICROWAVE-MODULATED LIGHT.**

L. K. Anderson (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

Electro-Technology, vol. 75, May 1965, p. 44-48. 16 refs.

Evaluation of devices which obtain information from modulated laser beams. Photoemissive detectors and solid-state photodetectors are discussed. Photoemissive detectors have poor quantum efficiency, limited life, and are complex; solid-state photodetectors have good quantum efficiency but low interaction impedance, and - in conventional use - no intrinsic current gain. When reasonable quantum efficiency, carrier multiplication, and low transit-time dispersion can be combined in a single device, substantial improvements will occur. Adequate performance throughout the visible spectrum will probably be realized by the high-speed photomultipliers now being developed. B. B.

## A65-24002

## OPTICAL COHERENCE AND PHOTON STATISTICS.

Roy J. Glauber (Harvard University, Cambridge, Mass.).  
IN: QUANTUM OPTICS AND ELECTRONICS; GRENOBLE, UNIVERSITY, SUMMER SCHOOL OF THEORETICAL PHYSICS, 1964 SESSION, LES HOUCHES, FRANCE, LECTURES. [A65-24000 13-16]  
Edited by C. DeWitt, A. Blandin, and C. Cohen-Tannoudji.  
Lectures sponsored by the Ministère de l'Education Nationale and NATO.  
New York, Gordon and Breach, Science Publishers, Inc., 1965, p. 63-185. 25 refs.

Study of the relation between optical coherence and photon statistics. A brief recapitulation of classical theory is given. Various interference experiments illustrating the coherence properties of light are described. Quantum theory is introduced, and the  $n$ th-order correlation function is derived. The photodetection process is considered for the cases of one-atom and  $n$ -atom photon detectors, and the probability that photoabsorption occurs during a given period of time is calculated. The analytical properties of the correlation functions and their relation to experimental measurements are investigated. Young's experiment is discussed at some length as an example typical of the interference experiments based on the measurement of a first-order correlation function. A simple classical description is given of the way in which the correlation fringes appear in the intensity interferometer when the field is produced by a pair of sources with small angular separation. Higher-order coherence and photon coincidences are considered. Methods are developed for discussing the photon statistics of arbitrary radiation fields in fully quantum-mechanical terms, extensive use being made of the coherent states of the field. It is shown that any quantum state of the field may be represented by a unique expansion in terms of the coherent states. Radiation by a predetermined charge-current distribution is studied. The use of the  $P$ -representation of the density operator to express phase-space distributions for the field is considered. The use of correlation functions to describe quasi-probability distributions is illustrated. Elementary models of light beams are described, including a model for ideal laser fields. Interference between independent light beams is discussed briefly. Various photon-counting experiments are evaluated. A. B. K.

## A65-24003

## OPTICAL PUMPING [POMPAGE OPTIQUE].

J. Brosset (Ecole Normale Supérieure, Paris, France).  
IN: QUANTUM OPTICS AND ELECTRONICS; GRENOBLE, UNIVERSITY, SUMMER SCHOOL OF THEORETICAL PHYSICS, 1964 SESSION, LES HOUCHES, FRANCE, LECTURES. [A65-24000 13-16]  
Edited by C. DeWitt, A. Blandin, and C. Cohen-Tannoudji.  
Lectures sponsored by the Ministère de l'Education Nationale and NATO.  
New York, Gordon and Breach, Science Publishers, Inc., 1965, p. 187-327. 114 refs. In French.

Description of optical-pumping experiments. The basic methods of producing and detecting an atomic orientation are described, the discussion being limited to a consideration of longitudinal parameters. The general characteristics of methods of optical pumping are outlined, the question of transverse parameters being considered. Practical applications of optical pumping are described. Relaxation processes are studied with the aid of optical methods. The relaxation of odd isotopes of mercury on

molten silica walls and of rubidium atoms on saturated paraffin coatings is considered. Collisions between a buffer gas and an atom undergoing optical pumping are studied for atoms in the excited state and in the ground state. Transitions induced by a definite type of photons in an atomic system involving several levels and transitions induced by the simultaneous action of several types of photons in a two-level system are investigated. The role of coherence in the multiple diffusion of light is considered. The effects of light on atomic-energy levels are analyzed in detail, a quantum theory of the optical-pumping cycle being developed. A physical interpretation of the theoretical results is given, and an experimental check of the findings is made. A. B. K.

## A65-24004

## THEORY OF OPTICAL MASERS.

W. E. Lamb, Jr. (Yale University, New Haven, Conn.).  
IN: QUANTUM OPTICS AND ELECTRONICS; GRENOBLE, UNIVERSITY, SUMMER SCHOOL OF THEORETICAL PHYSICS, 1964 SESSION, LES HOUCHES, FRANCE, LECTURES. [A65-24000 13-16]  
Edited by C. DeWitt, A. Blandin, and C. Cohen-Tannoudji.  
Lectures sponsored by the Ministère de l'Education Nationale and NATO.  
New York, Gordon and Breach, Science Publishers, Inc., 1965, p. 329-381. 25 refs.

Discussion of the theory of optical masers. Certain preliminary remarks are made concerning oscillators. A brief account is given of the quantum-theoretical and classical approach to spontaneous and stimulated emission of radiation. A classical model for maser action is described. The theory of the ammonia-beam maser is outlined. A theoretical model for the behavior of an optical maser is presented, in which the electromagnetic field is treated classically and the active medium is made up of thermally moving atoms which acquire nonlinear electric dipole moments under the action of the field according to the laws of quantum mechanics. The amplitudes and frequencies of multimode oscillation are determined as functions of the various parameters characterizing the maser. The linewidth of a laser oscillator is studied in some detail. A. B. K.

## A65-24005

## GASEOUS OPTICAL MASERS.

Ali Javan (Massachusetts Institute of Technology, Cambridge, Mass.).  
IN: QUANTUM OPTICS AND ELECTRONICS; GRENOBLE, UNIVERSITY, SUMMER SCHOOL OF THEORETICAL PHYSICS, 1964 SESSION, LES HOUCHES, FRANCE, LECTURES. [A65-24000 13-16]  
Edited by C. DeWitt, A. Blandin, and C. Cohen-Tannoudji.  
Lectures sponsored by the Ministère de l'Education Nationale and NATO.  
New York, Gordon and Breach, Science Publishers, Inc., 1965, p. 383-408.

Discussion of gaseous optical masers. The problem of a Doppler-broadened transition subject to an optical frequency field in the form of a standing wave is considered. Experimental observations of the saturation effect are emphasized, together with additional considerations involving manifestations of a number of pressure effects. The possibility of using a stimulated Raman effect when the Stokes-shifted line lies in the microwave range is mentioned. Certain collision processes which tend to bring partial thermal equilibrium within a group of atomic levels, while the overall atomic system remains nonthermodynamical, are investigated. The theory developed in this connection is directed toward discussions of certain distributions of populations which may in principle be realized in a gaseous discharge. By way of example, it is shown that a rather sizeable polarization of the nuclear spin of certain atomic species can be obtained in a high-pressure gaseous discharge in an external magnetic field. A formal discussion of an optical maser amplifier is presented, and the ultimate spectral width of an optical maser oscillator is derived. A. B. K.

**A65-24007****SOLID-STATE LASERS [LES LASERS A SOLIDES].**

P. Aigrain (Ecole Normale Supérieure, Paris, France).  
IN: QUANTUM OPTICS AND ELECTRONICS; GRENOBLE,  
UNIVERSITY, SUMMER SCHOOL OF THEORETICAL PHYSICS,  
1964 SESSION, LES HOUCHEs, FRANCE, LECTURES. [A65-  
24000 13-16]

Edited by C. DeWitt, A. Blandin, and C. Cohen-Tannoudji.  
Lectures sponsored by the Ministère de l'Education Nationale and  
NATO.  
New York, Gordon and Breach, Science Publishers, Inc., 1965,  
p. 523-553. In French.

Description of solid-state lasers with special emphasis on  
semiconductor lasers. Certain general remarks are made con-  
cerning pumping. Electronic-bombardment lasers using materials  
doped to various degrees are considered. The subject of p-n  
junction lasers is touched upon briefly. Lasers with a transparent  
solid matrix are investigated. The role of the matrix is analyzed,  
and widening of the absorption lines of an impurity in a solid  
matrix is considered. The problem of reabsorption from the solid  
state is discussed, as well as the nature of effectively utilized  
impurity-matrix systems. The dynamics of the operation of the  
solid-state laser are examined. Special mention is made of pulsed  
lasers and the limits on the power that can be obtained from them.  
Ruby amplifiers and oscillation modes of a crystal laser are dis-  
cussed briefly. The stimulated Raman effect obtained with the aid  
of pulsed ruby lasers is described. A. B. K.

**A65-24011 #****A PARAMAGNETIC MASER AMPLIFIER WITH COUPLED ACTIVE  
CAVITIES OPERATING AT A WAVELENGTH OF 21 CM.**

R. M. Martirosian and A. M. Prokhorov.  
(Radiotekhnika i Elektronika, vol. 9, Dec. 1964, p. 2094-2098.)  
Radio Engineering and Electronic Physics, vol. 9, Dec. 1964,  
p. 1741-1744. 5 refs. Translation.  
[For abstract see Accession no. A65-14136 05-09]

**A65-24012 #****THE PASSBAND OF A MULTICAVITY PARAMAGNETIC MASER  
AMPLIFIER.**

V. B. Steinsheleiger and G. S. Miseshnikov.  
(Radiotekhnika i Elektronika, vol. 9, Dec. 1964, p. 2099-2104.)  
Radio Engineering and Electronic Physics, vol. 9, Dec. 1964,  
p. 1744-1749. 8 refs. Translation.  
[For abstract see Accession no. A65-14137 05-09]

**A65-24019 #****THE STABILIZATION OF AN UNSTABLE MODE OF OPERATION  
IN A TWO-LEVEL MASER.**

A. S. Agabekian, A. Z. Grasiuk, I. G. Zubarev, V. I. Svergun,  
and A. N. Oraevskii.  
(Radiotekhnika i Elektronika, vol. 9, Dec. 1964, p. 2156-2165.)  
Radio Engineering and Electronic Physics, vol. 9, Dec. 1964,  
p. 1790-1797. 6 refs. Translation.  
[For abstract see Accession no. A65-14144 05-16]

**A65-24038 #****ON CALCULATING THE NONSTATIONARY PROCESSES IN  
LASERS.**

A. L. Mikaelian, M. L. Ter-Mikaelian, and Iu. G. Turkov.  
(Radiotekhnika i Elektronika, vol. 9, Oct. 1964, p. 1788-1799.)  
Radio Engineering and Electronic Physics, vol. 9, Oct. 1964,  
p. 1482-1491. 8 refs. Translation.

**A65-24083 #****VISUAL OBSERVATION OF INFRARED LASER RADIATION  
[O VIZUAL'NOM NABLUDENII INFRAKRASNOGO IZLUCHENIIA  
OPTICHESKOGO KVANTOVOGO GENERATORA].**

L. S. Vasilenko, V. P. Chebotaev, and Iu. V. Troitskii (Akademiia  
Nauk SSSR, Sibirskoe Otdelenie, Institut Radiofiziki i Elektroniki,  
Novosibirsk, USSR).

Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Mar.  
1965, p. 777, 778. In Russian.

Description of experiments in visual perception of intense  
coherent infrared radiation. Radiation of 0.95, 1.11, 1.15, and  
1.18  $\mu$  from a gas laser was observed with the unaided eye. Radia-  
tion with  $\lambda = 0.95 \mu$  is perceived as red light, while radiation with  
 $\lambda = 1.11, 1.15,$  and  $1.18 \mu$  is perceived as light with half the wave-  
length of red light. (Author) A. B. K.

**A65-24084 #****INVESTIGATION OF A LARGE-CURRENT NEON-HYDROGEN  
LASER [ISSLEDOVANIIE OPTICHESKOGO KVANTOVOGO  
GENERATORA NA SMESI NEON-VODOROD PRI BOL'SHIKH  
TOKAKH RAZRIADA].**

V. P. Chebotaev and L. S. Vasilenko (Akademiia Nauk SSSR,  
Sibirskoe Otdelenie, Institut Radiofiziki i Elektroniki, Novosibirsk,  
USSR).

Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Mar.  
1965, p. 779-781. In Russian.

Results of an investigation of the emission spectrum of a neon-  
hydrogen laser for the case of high current densities in the hollow  
cathode. Seventeen lines of the  $2s-2p$  transition series of neon in  
the range from 0.94 to 1.4  $\mu$  are produced at a cathode current den-  
sity of 260 ma/cm<sup>2</sup>. (Author) A. B. K.

**A65-24085 #****SPECTRAL AND TIME CHARACTERISTICS OF STIMULATED  
RADIATION FROM  $\text{CaF}_2:\text{Sm}^{2+}$  [SPEKTRAL'NYE I VREMENNYE  
KHARAKTERISTIKI STIMULIROVANNOGO IZLUCHENIIA  
 $\text{CaF}_2:\text{Sm}^{2+}$ ].**

Iu. A. Anan'ev and B. M. Sedov.  
Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Mar.  
1965, p. 782-790. 18 refs. In Russian.

Experimental investigation of the spectrum of the stimulated  
radiation from  $\text{CaF}_2:\text{Sm}^{2+}$ . The distribution of the radiation with  
respect to axial oscillation modes is studied. A continuous suc-  
cession of transverse oscillation modes is observed under steady-  
state-emission conditions. It is demonstrated that the absence of  
oscillations in the integral radiation from  $\text{CaF}_2:\text{Sm}^{2+}$  is due to the  
superposition of a large number of spikes over a certain period of  
time, these spikes corresponding to various transverse oscillation  
modes. Information on the spatial distribution of various oscilla-  
tion modes in the radiation is obtained. (Author) A. B. K.

**A65-24088 #****EMISSION OF MONOPULSES OF COHERENT LIGHT BY A TWO-  
COMPONENT MEDIUM WITH NEGATIVE ABSORPTION  
[IZLUCHENIE MONOIMPUL'SOV KOGERENTNOGO SVETA  
DVUKH-KOMPONENTNOI SREDOI S OTRITSATEL'NYM  
POGLOSHCHENIEM].**

V. I. Borodulin, N. A. Ermakova, L. A. Rivlin, and V. S.  
Shil'diaev.  
Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Mar.  
1965, p. 845-849. 8 refs. In Russian.

Consideration of the excitation of auto-oscillations in a medium  
which is located in a Fabry-Pérot resonator and contains two types  
of quantum oscillators with equal energy transitions. For a certain  
relation between the parameters such a medium emits monopulses  
of light. The shape, energy, amplitude, and duration of a mono-  
pulse are determined. Monopulse emission from a medium con-  
sisting of ruby single crystals and KS-19 glass plates was observed  
experimentally. However, the applicability of this mechanism to  
the experimental results requires a special analysis. (Author) A. B. K.

**A65-24130 #****INJECTION LASERS.**

Walter L. Knecht (USAF, Systems Command, Research and Tech-  
nology Div., Avionics Laboratory, Wright-Patterson AFB, Ohio).  
IN: NATIONAL AEROSPACE ELECTRONICS CONFERENCE,  
DAYTON, OHIO, MAY 11-13, 1964, PROCEEDINGS. [A65-24101  
13-09]



## A65-24131

Conference sponsored by the Professional Group on Aerospace and Navigational Electronics, Dayton Section of the Institute of Electrical and Electronics Engineers, and American Institute of Aeronautics and Astronautics.

Dayton, Institute of Electrical and Electronics Engineers, Dayton Section, 1964, p. 240-244.

Review of the properties and behavior of gallium arsenide injection lasers. The fabrication and inherent capabilities of GaAs and mixed-crystal injection lasers are described. The performance characteristics of GaAs lasers are discussed and are compared with those of other types of lasers. The GaAs laser is shown to surpass any other laser with regard to efficiency and CW-power output. Applications for injection lasers are described. P. K.

## A65-24131 #

### REVIEW OF LASER APPLICATIONS.

George R. White (Electro-Optical Systems, Inc., Pasadena, Calif.).

IN: NATIONAL AEROSPACE ELECTRONICS CONFERENCE, DAYTON, OHIO, MAY 11-13, 1964, PROCEEDINGS. [A65-24101 13-09]

Conference sponsored by the Professional Group on Aerospace and Navigational Electronics, Dayton Section of the Institute of Electrical and Electronics Engineers, and American Institute of Aeronautics and Astronautics.

Dayton, Institute of Electrical and Electronics Engineers, Dayton Section, 1964, p. 246-251.

Discussion of the properties, behavior, and potential applications of various types of lasers. The laser types considered are ruby, neon-helium gas, gallium arsenide injection, neodymium in calcium tungstate, and pulsed neodymium in glass; the KDP harmonic oscillator is also discussed. Applications are described for radar, instrumentation (including instruments for medicine, spectroscopy, micromachining, and microwelding), navigation, and communications. P. K.

## A65-24189 #

### NEODYMIUM GLASS LASER AND ITS OPTICAL CHARACTERISTICS.

Masahide Kamiyama (Tokyo, University, Dept. of Electronic Engineering, Tokyo, Japan).

Tokyo, University, Faculty of Engineering, Journal, Series A, no. 2, 1964, p. 30, 31. In Japanese.

Investigation of stimulated emission in a glass laser containing neodymium. Silicate glass is used as the base material because it best emits the fluorescence of  $\text{Nd}^{+3}$ . Glass rods have a low threshold value when containing 2 to 5%  $\text{Nd}_2\text{O}_3$  as could be expected from the relation of fluorescence to neodymium concentration. Emission spectra of  $\text{Nd}^{+3}$  in glass laser rods are also observed. Cavity modes and broadening of fluorescence lines are investigated, and experimental results are detailed. (Author) B. B.

## A65-24276

### LOCKING OF He-Ne LASER MODES BY INTRACAVITY ACOUSTIC MODULATION IN COUPLED INTERFEROMETERS.

M. Didomenico, Jr. and V. Czarniewski (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

Applied Physics Letters, vol. 6, Apr. 15, 1965, p. 150-152. 6 refs.

A report on mode-locking experiments in a 6328 Å He-Ne laser by means of synchronous intracavity acoustic modulation in coupled multimode confocal interferometers. The major innovation in this experimental work is that the internal loss modulation is performed in a separate resonator coupled to the laser resonator. The practical advantage of placing the modulator in a coupled interferometer is that it leaves the laser interferometer essentially undisturbed and puts most of the optical loss of the system into a weakly coupled resonator, although this does result in some decrease in the available power output of the laser. Mode locking, which is illustrated in the text, is obtained by placing the coupled interferometers in the confocal configuration, with the coupling mirror  $M_2$  located at

the common focal plane of mirrors  $M_1$  and  $M_3$ . Mode locking was found to occur as the acoustic exciting frequency was tuned near 50 Mc. Several other experiments were performed to determine the sensitivity of the locking to variations in some of the parameters of the system. D. P. F.

## A65-24280

### MEASUREMENT OF PARAMETRIC GAIN ACCOMPANYING OPTICAL DIFFERENCE FREQUENCY GENERATION.

Charles C. Wang and George W. Racette (Philco Corp., Applied Research Laboratory, Blue Bell, Pa.).

Applied Physics Letters, vol. 6, Apr. 15, 1965, p. 169-171. 15 refs. Contract No. AF 30(602)-3364.

A description of the method used to obtain parametric amplification of a light beam of 6328 Å by the second harmonic frequency at 3469 Å, of the stimulated radiation from ruby laser crystals. Results indicate that the parametric gain is of the order of 1 db. The experimental arrangement consists of a He-Ne gas laser, operating at 6328 Å, which provides a signal beam of  $10^{-2}$  watt. An ultra-high-quality Linde ruby rod with 60° orientation, 1/4 in. in diameter and 3 in. long, is Q-switched to provide an output pulse of 30 mw peak power and 30 nsec width, at half-intensity points. An ADP crystal 8 cm in length was placed in the unfocused ruby laser beam and oriented to that the index matching condition was satisfied for second harmonic generation. The second harmonic thus generated provided the pump power for parametric amplification. At the second ADP crystal pump power at 3469 Å was found to be about 2 mw. Pump and signal beams were aligned using Polaroid films. With signal power of 8.2 mw at the ADP crystal, the maximum difference frequency generated was found to be about 1.2 mw, corresponding to a power amplification of 17.6%. D. P. F.

## A65-24282

### A LOW-TENSION DISCHARGE OF VERY HIGH INTENSITY STARTED BY LASER PULSES [DECHARGE BASSE TENSION A TRES HAUTE INTENSITE INITIEE PAR IMPULSION LASER].

Germain Chartier and Albert Septier (Paris, Université, Institut d'Electronique, Orsay, Seine-et-Oise, France), Académie des Sciences (Paris), Comptes Rendus, vol. 260, no. 18, May 3, 1965, p. 4685-4688. 8 refs. In French.

A description of the results obtained by focusing the luminous beam from a ruby laser onto a titanium hydride target which acts as one of the electrodes of a diode, whereby pulses of current attain an intensity of several hundreds of amperes for several  $\mu$  sec. This procedure facilitates the formation of very dense discharges, or it can be used as a high-intensity ion source. D. P. F.

## A65-24309

### HYDROGEN-MASER PRINCIPLES AND TECHNIQUES.

D. Kleppner, H. C. Berg, S. B. Crampton, N. F. Ramsey (Harvard University, Cambridge, Mass.), R. F. C. Vessot, H. E. Peters, and J. Vanier (Varian Associates, Beverly, Mass.).

Physical Review, 2nd Series, Section A, vol. 138, May 17, 1965, p. A 972-A 983. 32 refs.

NSF-Navy-NASA-supported research.

Details of the techniques and design principles relevant to the construction and operation of a hydrogen maser. These include methods for the generation of atomic hydrogen, state selection, design of the microwave cavity, production of very low magnetic fields, coating the hydrogen storage bulb, and tuning the maser. A figure of merit is introduced which indicates the optimum choice of parameters. (Author) W. M. R.

## A65-24352

### LASER MICROWELDING.

James R. Shackleton (Hughes Aircraft Co., Ground Systems Group, Fullerton, Calif.).

Semiconductor Products and Solid State Technology, vol. 8, May 1965, p. 15-19.

Discussion of the capabilities, characteristics, and applications of the laser microwelding technique for the formation of small electrical joints. Applications covered include welds to thin films and between dissimilar materials of widely different thicknesses, and the formation of electrical connections directly through a sheet of insulated material. Preliminary tests on laser microwelding are briefly discussed, and the effects of various thin-film circuit substrates on the quality of the weld are examined. P. K.

#### A65-24683

##### DETERMINATION OF THE REFRACTIVE INDEX OF A SOLID USING A FAR INFRARED MASER.

J. E. Chamberlain and H. A. Gebbie (National Physical Laboratory, Basic Physics Div., Teddington, Middx., England). *Nature*, vol. 206, May 8, 1965, p. 602, 603. 5 refs.

Description of a method, using a far IR Michelson interferometer illuminated with the 337-micron radiation from a CN maser, for determining the refractive index of a solid. The method is reviewed, and its application to measure the refractive indices of polythene, polytetrafluorethylene, and crystalline quartz is described. The results support those obtained by Fourier methods. It is noted that the combination of maser and Fourier methods can be used for precision IR dispersion measurements on materials in any phase. P. K.

#### A65-24781

##### PRECISION RANGE-GATED IMAGING TECHNIQUE.

Don B. Neumann (USAF, Systems Command, Research and Technology Div., Avionics Laboratory, Wright-Patterson AFB, Ohio). (Society of Motion Picture and Television Engineers, Technical Conference, New York, N.Y., Sept. 28, 1964.) *SMPTE, Journal*, vol. 74, pt. 1, Apr. 1965, p. 313-319.

Use of a Q-switched giant-pulsed laser to actively illuminate a distant target with a light pulse of about 60-nsec duration. The 50-nsec exposure of an image-converter camera is delayed the proper amount with respect to the laser to allow light only from the target area to enter the camera, thus limiting the image to objects within the target area. It is demonstrated that backscatter from such atmospheric particles as rain and snow can be much reduced by this technique and that such range information as elevation contours can be inserted in an aerial photograph. Both factors appear to be limited in range and field of view only by the output energy from lasers presently available. B. B.

#### A65-24809 #

##### STATISTICAL CHARACTERISTICS OF AUTOMODULATION OF THE EMISSION OF A SOLID-STATE LASER (STATISTICHESKIE KHARAKTERISTIKI AVTOMODULIATSII IZLUCHENIIA LAZERA NA TVERDOM TELE).

V. I. Bespalov and A. V. Gaponov (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Institut, Gorki, USSR). *Radiofizika*, vol. 8, no. 1, 1965, p. 70-80. 10 refs. In Russian.

Consideration of the effect of spontaneous emission on the behavior of a system of two-level objectives with different longitudinal ( $T_1$ ) and transverse ( $T_2$ ) relaxation times in a single-mode resonator ( $T_2 \ll T_1$ ). It is shown that spontaneous emission leads, on the average, to more rapid attenuation of the emission modulation under transient conditions. The maximum power in the "peaks" of the emission of a solid-state laser is found, this quantity being logarithmically related to the intensity of the spontaneous emission. A. B. K.

#### A65-24810 #

##### NATURAL MODES OF OPTICAL QUANTUM RESONATORS WITH DIELECTRIC FILLING (SOBSTVENNYE TIPY KOLEBANIY KVANTOVYKH OPTICHESKIKH REZONATOROV, ZAPOLNEN-NYKH VESHCHESTVOM).

A. N. Oraevskii and V. A. Shcheglov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Radiofizika*, vol. 8, no. 1, 1965, p. 81-90. 10 refs. In Russian.

Investigation of the natural modes of plane and cylindrical dielectric resonators in the optical band. The transverse wave numbers and the natural frequencies are calculated. The quality factors of the modes are found. The number of natural oscillations in a given spectral interval is determined. (Author) A. B. K.

#### A65-24811 #

##### STEADY-STATE LASER OSCILLATIONS WITH DISTRIBUTED LOSSES [OB USTANOVIVSHISIA KOLEBANIY LAZERA S RASPREDELENNYMI POTERIAMI].

L. A. Ostrovskii and E. I. Iakubovich (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

*Radiofizika*, vol. 8, no. 1, 1965, p. 91-97. In Russian.

Consideration of electromagnetic oscillations in a plane active layer. It is taken into account that the energy losses in such a system may be caused not only by radiation through the layer boundaries but also by losses in the medium containing the active molecules. The frequency spectrum of steady-state nonlinear oscillations is found, as well as the corresponding amplitude and phase distributions of the field in space. It is shown, in particular, that the presence of volume losses in sufficiently thick layers leads to an ambiguous spatial dependence of the field at the given frequency. (Author) A. B. K.

#### A65-24824 #

##### OBSERVATION OF MULTIBEAM GENERATION OF A HELIUM-NEON LASER [NABLIUDENIE MNOGOPUCHKOVOGO REZHIMA GENERATSII GELII-NEONOVOGO LAZERA].

Iu. I. Zaitsev and D. P. Stepanov (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

*Radiofizika*, vol. 8, no. 1, 1965, p. 198, 199. In Russian.

Observation of multibeam generation of a helium-neon laser in a gas-discharge tube. The multibeam generation was produced by introducing into the resonator of the generating laser inhomogeneities either in the form of a flat tapered plate lying approximately at a Brewster angle to the emission beam or in the form of opaque objects (such as a segment of wire) perpendicular to the axis of the beam. When spherical mirrors and tapered plates are used, an emission structure consisting of two beams converging on one mirror at angles up to 20° can easily be obtained. By replacing one of the spherical mirrors with a flat mirror, a two-beam "angle" mode can be excited. A single emission structure consisting of up to eight beams can be excited with the aid of a plate and up to four beams with the aid of a wire segment. A. B. K.

#### A65-24825 #

##### THE EXCITATION PARAMETER OF A BEAM MASER [O PARAMETRE VOZBUZHDENIIA PUCHKOVOGO MAZERA].

A. F. Krupnov and V. A. Skvortsov (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

*Radiofizika*, vol. 8, no. 1, 1965, p. 200-203. 9 refs. In Russian.

Calculation of the maximum obtainable excitation parameter of a beam maser, taking into account a quantitative estimate of the effect of collisions in the beam. The results obtained are compared with data from experiments with a formaldehyde molecular generator. The dependence of the excitation parameter on the magnitude of the molecular beam and on the length of the sorting system is found, taking collisions into account. A. B. K.

#### A65-24857 #

##### POLARIZATION OF LASER RADIATION.

A. M. Ratner.

(Optika i Spektroskopiia, vol. 18, Feb. 1965, p. 258-266.)

*Optics and Spectroscopy*, vol. 18, Feb. 1965, p. 143-147. 7 refs.

Translation.

[For abstract see Accession no. A65-21805 11-16]

## A65-24862

### A65-24862 #

ON SOME FEATURES OF GAS LASERS CONTAINING MIXTURES OF OXYGEN AND RARE GASES.

S. G. Rautian and P. L. Rubin.

(Optika i Spektroskopiia, vol. 18, Feb. 1965, p. 326-328.)

Optics and Spectroscopy, vol. 18, Feb. 1965, p. 180, 181. 9 refs.

Translation.

[For abstract see Accession no. A65-21810 11-16]

### A65-24863 #

SPECTROSCOPIC APPLICATIONS OF GAS LASERS.

G. G. Petrash and S. G. Rautian.

(Optika i Spektroskopiia, vol. 18, Feb. 1965, p. 336, 337.)

Optics and Spectroscopy, vol. 18, Feb. 1965, p. 188, 189.

Translation.

[For abstract see Accession no. A65-21811 11-16]

### A65-24879 #

LIMITS ON THE CROSS SECTION OF A LASER BEAM [PREDEL' - NOE SECHENIE PUCHKA IZLUCHENIIA OPTICHESKOGO KVANTOVOGO GENERATORA].

N. G. Basov, E. M. Belenov, and V. S. Letokhov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Akademiia Nauk SSSR, Doklady, vol. 161, Apr. 1, 1965, p. 799-801. 5 refs. In Russian.

Analysis showing that for CW-lasers with large transverse dimensions of the resonant cavity, limits on the cross section of the output beam can arise because of delayed interaction in the far fields of the laser or due to mismatch of the self-resonant frequencies of the individual resonator components. In pulsed Q-switched lasers, limits on the beam cross section can occur when the time of radiation buildup by the crystal is of the order of the transient period of the types of resonator oscillations.

V. P.

### A65-24881 #

OPTICAL MASER USING  $\text{CaF}_2:\text{Dy}^{2+}$  [KVANTOVYI OPTICHESKII GENERATOR NA  $\text{CaF}_2:\text{Dy}^{2+}$ ].

V. V. Kostin, T. M. Murina, A. M. Prokhorov, and V. T. Udo-venchik (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Akademiia Nauk SSSR, Doklady, vol. 161, Apr. 1, 1965, p. 806-809. 8 refs. In Russian.

Experimental investigation of a laser using a fluorite crystal containing the bivalent dysprosium ion in various concentrations. The luminescence and absorption spectra of these crystals are studied. The absorption spectrum is found to consist of a strong absorption band, reaching from 2300 to 4900 Å, and of three less strong but narrow bands having maxima at the wavelengths 5800, 7150, and 9100 Å, respectively. Pumping (with xenon lamps) of any of these three lines leads to strong luminescence in the region of 2.3 to 2.6 μ. Spectrograms of the emission line are presented, and the latter is found to equal 0.01 cm<sup>-1</sup>.

V. P.

### A65-24882 #

APPLICATION OF A TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER TO RADIO-ASTRONOMICAL INVESTIGATIONS IN THE 8-CM BAND [PRIMENENIE KVANTOVOGO PARAMAGNETNOGO USILITELIA BEGUSHCHEI VOLNY DLIIA RADIOASTRONOMICHESKIKH ISSLEDOVANIÍ NA VOLNE 8 SM].

L. I. Matvenko, G. S. Mizezhnikov, M. M. Mukhina, and V. B. Shteinshteyger.

Akademiia Nauk SSSR, Doklady, vol. 161, Apr. 1, 1965, p. 810-812. In Russian.

Description of a radio telescope coupled to a traveling-wave quantum paramagnetic amplifier using a ruby crystal with a Cr<sup>3+</sup> concentration of 0.036%. The block diagram of the device is discussed. The radio emission from Signus A, Jupiter, and the galactic M-82 obtained at a time constant of 2, 10, and 4 sec, respectively, is plotted. Techniques are described, using which it

proved possible to obtain a stability of better than 2% for the amplification factor of the radio telescope over a period of operation of 1 hr, a modulation frequency of 179 cps, and a transmission band of 10 cps for the modulation-frequency amplifier.

V. P.

### A65-24910

THE OPTICAL RING RESONATOR.

W. W. Rigrod (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).

Bell System Technical Journal, vol. 44, May-June 1965, p. 907-916. 13 refs.

Derivation of expressions for the stability parameter, spot size, and a wavefront curvature of a Gaussian beam in a ring resonator containing up to four spherical mirrors unequally spaced. Higher-order transverse modes and aperture effects are not considered. Two methods of analysis are used: (1) replacement of the mirrors by an infinite sequence of equally spaced identical thick lenses, and (2) transformation of the beam into itself after one circuit of the ring, by means of a ray matrix representation of the equivalent thin lenses. The procedure can readily be extended to ring resonators with any number of spherical mirrors.

(Author) M. M.

### A65-24911

DIFFRACTION LOSS AND SELECTION OF MODES IN MASER RESONATORS WITH CIRCULAR MIRRORS.

Tingye Li (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).

Bell System Technical Journal, vol. 44, May-June 1965, p. 917-932. 18 refs.

Computation of the losses, phase shifts, and field distribution functions for the two lowest-order modes on interferometer-type maser resonators consisting of spherically curved mirrors with circular apertures, by solving a pair of integral equations numerically on a digital computer. Solutions are obtained for the symmetric geometry of identically curved mirrors and for the half-symmetric geometry consisting of one plane and one curved mirror, with the radius of curvature of the mirrors as a variable parameter. The confocal or near-confocal configuration is shown to have good mode-selective properties in that the ratio of the loss of the second-order (TEM<sub>10</sub>) mode to that of the lowest-order (TEM<sub>00</sub>) mode is the largest of the configurations considered. It is noted that the numerical results should be of interest to those concerned with the problem of mode selection in optical masers and with the design of single-mode masers with relatively low gain.

(Author) M. M.

### A65-24931 #

SIGNAL DEGENERATION IN LASER BEAMS PROPAGATED THROUGH A TURBULENT ATMOSPHERE.

Petr Beckmann (Colorado, University, Dept. of Electrical Engineering, Boulder, Colo.).

Journal of Research, Section D - Radio Science, vol. 69D, Apr. 1965, p. 629-640. 14 refs.

NBS-supported research.

Derivation of the statistical distribution of the angle of arrival, the spot location, the cross section, the amplitude, the carrier phase, and the modulation phase of a laser beam traversing an anisotropically turbulent atmosphere, in terms of the space correlation function of the atmospheric index of refraction and the wind-speed. The limitations imposed by the turbulent atmosphere and the loss of coherence on the depth and bandwidth of the modulation, on the length of the path, and on the aperture of the receiving apparatus are analyzed. Experiments to obtain numerical parameters and to check functional dependencies are proposed.

(Author) M. M.

### A65-24933

A 4-MM FABRY-PEROT MASER.

A. F. Krupnov and V. A. Skvortsov (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorki, USSR).

(Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 47, Nov. 1964, p. 1605-1611.)

Soviet Physics - JETP, vol. 20, May 1965, p. 1079-1083. 15 refs.

Translation.

[For abstract see Accession no. A65-14113 05-16]

**A65-24951****STUDY OF THE "SPARK" PRODUCED IN AIR BY FOCUSED LASER RADIATION.**

S. L. Mandel'shtam, P. P. Pashinin, A. V. Prokhindiev, A. M. Prokhorov, and N. K. Sukhodrev (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). (*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 47, Nov. 1964, p. 2003-2005.)

*Soviet Physics - JETP*, vol. 20, May 1965, p. 1344-1346. 7 refs. Translation.

[For abstract see Accession no. A65-14131 05-16]

**A65-24954****PROBLEM OF SPIKE ELIMINATION IN LASERS.**

H. Stutz, G. A. DeMars, D. T. Wilson (Raytheon Co., Research Div., Waltham, Mass.), and C. L. Tang (Cornell University, Dept. of Electrical Engineering, Ithaca, N.Y.).

*Journal of Applied Physics*, vol. 36, May 1965, p. 1510-1514.

10 refs.

Contract No. AF 19(628)-3862.

Theoretical and experimental investigation of the conditions under which spiking in a laser output can be completely suppressed. It is predicted that a nonlinear absorber in the cavity producing greater loss at the higher power levels, and vice versa, should be highly effective. Experimental work was carried out with a single-mode traveling-wave laser, since in this case the predictions can be most easily checked. Instead of using a nonlinear absorber, a Kerr cell controlled by a feedback circuit was used. It was found, in agreement with theory, that the time delay between the buildup of the electromagnetic energy in the cavity and the corrective action of the Kerr cell is a rather important parameter. Spike suppression can only be obtained when this time delay is short as compared to the duration of one oscillation pulse. (Author) A.B.K.

**A65-24956****LASER-INDUCED THERMIONIC EMISSION FROM TANTALUM.**

C. M. Verber and A. H. Adelman (Battelle Memorial Institute, Columbus, Ohio).

*Journal of Applied Physics*, vol. 36, May 1965, p. 1522-1525.

6 refs.

Grant No. AF AFOSR 640-64.

Measurement of the induced thermionic emission of electrons from tantalum as a result of bombardment with laser beams of up to  $10^5$  w/cm<sup>2</sup> peak power, the emission being expressed as a function of the tantalum temperature. It is shown that, within the power range investigated, the results can be described in detail as thermionic emission resulting from a temperature increase which is calculable from classical heat-transfer theory. (Author) A.B.K.

**A65-24960****THEORY OF LASER GIANT PULSING BY A SATURABLE ABSORBER.**

A. Szabo (National Research Council, Div. of Radio and Electrical Engineering, Ottawa, Canada), and R. A. Stein (Alberta, University, Dept. of Electrical Engineering, Edmonton, Alberta, Canada).

*Journal of Applied Physics*, vol. 36, May 1965, p. 1562-1566.

26 refs.

Analysis of laser giant pulsing, using a saturable absorber inside the laser cavity as a fast switch. Giant pulse parameters such as pulse rise and fall times and peak power are calculated as a function of  $\sigma$ , the ratio between the ion cross section of the absorber and that of the laser;  $n_{ai}$ , the normalized inversion prior to switching; and the laser mirror transmission  $T_r$ . It is shown that there is an optimum  $T_r$  for the extraction of maximum peak power. A criterion for the minimum  $\sigma$  for giant pulsing to occur is derived. The largest output occurs when  $\sigma \sim \sigma_c$ , in which case the theory approaches that of Wagner and Lengyel. Some numerical examples are presented, as well as a discussion of the range of validity of the theory. (Author) A.B.K.

**A65-24961****MAGNETIC PROPERTIES OF InAs DIODE ELECTROLUMINESCENCE.**

F. L. Galeener (Massachusetts Institute of Technology, National Magnet Laboratory, Lexington, Mass.), I. Melngailis, G. B. Wright, and R. H. Rediker (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).

*Journal of Applied Physics*, vol. 36, May 1965, p. 1574-1579.

25 refs.

Study of spontaneous and laser electroluminescence of InAs diodes in magnetic fields up to 109 kgauss. The peak of the emitted energy shifts linearly with magnetic fields above 20 kgauss at a rate which depends on the carrier concentration of the n-type base material. If the energy shift is described as  $\Delta E = 1/2 \mu_B m^* c$ , the value of  $m^*$  is the same as that measured at the Fermi level in bulk n-type material. The emission from one laser diode exhibited a splitting which corresponds to a g factor of about 7 for the electron. Evidence was obtained that the laser threshold current is reduced by the magnetic-field component perpendicular to the junction current. (Author) A.B.K.

**A65-24964****MICROWAVE PROPERTIES OF A CALCIUM-VANADIUM-BISMUTH GARNET.**

W. G. Nilsen and E. G. Spencer (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

*Journal of Applied Physics*, vol. 36, May 1965, p. 1616-1619.

8 refs.

Measurement of the microwave properties of single crystals of the garnet  $\{Ca_{2.5}Bi_{0.5}\}[Fe_2](Fe_{1.75}V_{1.25})O_{12}$  from 4.2°K to room temperature. Its linewidth is found to be quite small, varying from 1.5 to 9 oe, depending on temperature and orientation. Considering the small saturation magnetization of this garnet ( $4\pi M = 610$  gauss) the magnetic-anisotropy field is unusually low at 4.2°K, namely, about 275 oe along the easy axis of magnetization. The calcium-vanadium-bismuth garnets have been found to be particularly useful in isolators for traveling-wave masers. Because of the unique combinations of low anisotropy and low magnetization, operation can be obtained at lower frequencies in the frequency-magnetic field region near  $g = 2$  than for pure or substituted yttrium iron garnet. The characteristics of such an isolator operating at 1750 Mc/sec and 300 oe are described. (Author) A.B.K.

**A65-24976 #****SPECTRAL STUDIES OF RUBY LASER EMISSION AND OF ITS RELATION TO RESONATOR PROPERTIES [ISSLEDOVANIE SPEKTRA IZLUCHENIYA RUBINOVOGO LAZERA I EGO SVYAZI SO SVOISTVAMI REZONATORA].**

F. A. Korolev and S. M. Mamedzade (Moskovskii Gosudarstvennyi Universitet, Kafedra Optiki, Moscow, USSR).

*Moskovskii Universitet, Vestnik, Seriya III - Fizika, Astronomiya*, vol. 20, Mar.-Apr. 1965, p. 35-39. 13 refs. In Russian.

Study of the types of resonance oscillations in ruby laser emission at room temperature, using a Fabry-Pérot multiplex etalon and a ruby crystal of such a shape that its outer dielectric mirrors and end faces form a complex resonator producing oscillations of various types. It is shown that the spectral composition of stimulated ruby emission depends closely on the resonator structure, showing spectral components which correspond to components of the resonator. A multiplex etalon proved effective in resolving the superfine spectral structure in laser emission. V. Z.

**A65-25036****QUANTUM ELECTRODYNAMICS AND GUIDANCE [ELECTRONIQUE QUANTIQUE ET GUIDAGE].**

G. Pircher (Compagnie Française Thomson-Houston, Service d'Etudes Techniques Avancées, Paris, France).

*Technique et Science Aéronautiques et Spatiales*, Jan.-Feb. 1965, p. 39-44. In French.

Use of quantum electrodynamics as a means of greatly increasing the accuracy of locating an object in space and time and of correcting its movements. Quantum electrodynamics involves the study of

processes of emission and amplification, while taking quantum processes directly into consideration. Some examples concerning the use of masers, lasers, and atomic clocks are given. Expanding the subject, it is shown how the inexactness of knowledge of space-time parameters is related to uncertain knowledge of the characteristics of the electromagnetic waves carrying the information. These characteristics are related to the concept of the coherence of these waves. The concept and its evolution in various emission and amplification processes are briefly examined. F.R.L.

#### A65-25059

##### PHENOMENOLOGICAL THEORY OF LASER BEAM FLUCTUATIONS AND BEAM MIXING.

L. Mandel (Rochester, University, Dept. of Physics and Astronomy, Rochester, N. Y.).

*Physical Review, 2nd Series*, vol. 138, May 10, 1965, p. B 753-B 762. 42 refs.

Army-USAF-supported research.

Quantum theoretical analysis of laser beam fluctuations and of the light beat experiments with two lasers. With the help of experimental results on photon counting fluctuations in a single-mode laser field, some correlation properties of the field are derived. It is shown that the correlation equations are satisfied by states of the field which are much more general than "coherent" states. The equations lead directly to the spectral density of the intensity operator in the light beat experiments, which can be obtained from photoelectric measurements. The resulting expression is practically identical to that found by Forrester for light having thermal statistical properties. The reasons for this are discussed by a comparison of the corresponding probability distributions of photon counts and of the classical wave amplitude. (Author) W.M.R.

#### A65-25256 \*

##### QUANTUM ELECTRONICS [KVANTOVAIA ELEKTRONIKA].

A. M. Prokhorov.

*Uspekhi Fizicheskikh Nauk*, vol. 85, Apr. 1965, p. 599-604. 15 refs. In Russian.

Historical review of quantum electronics. The reasons why the first advances in quantum electronics were made by scientists working in the field of radio spectroscopy and not by those working in the field of optical spectroscopy are outlined. Certain difficulties standing in the way of the creation of optical quantum generators even after the creation of masers in the radio range are discussed. It is shown that, although these difficulties have now been mastered in the case of optical quantum generators, these same difficulties have cropped up again in the case of generators in the X-ray range. It is said that a new qualitative leap has been made in obtaining from a ruby oscillator energy densities at which the probability of multiquantum processes is commensurate with or exceeds the probability of single-quantum processes. The creation of quantum generators using two-quantum transitions is cited as being an interesting and fundamentally new trend. A.B.K.

#### A65-25265

##### COHERENCE-PROPERTIES OF THE STATISTICAL OPERATOR IN A LASER MODEL.

W. Weidlich and F. Haake (Stuttgart, Technische Hochschule, Institut für theoretische und angewandte Physik, Stuttgart, West Germany).

*Zeitschrift für Physik*, vol. 185, no. 1, 1965, p. 30-47. 14 refs.

Investigation of the coherence properties of the statistical operator  $R$  of a field of light, for a laser system. Starting from the Schrödinger equation for motion for the statistical operator  $W$  of the system [atoms + field], it is shown that such an equation has "coherent" terms derived from the Hamiltonian  $H = H_A$  (atoms) +  $H_F$  (fields) +  $H_I$  (interaction), and "incoherent" terms arising from the coupling of the active atom levels to the pumped levels and to the ground state and the coupling of the lightmode to the absorbing material.  $W = \rho$  (atoms)  $\times$   $R$  (field). The complete equation of motion is solved and leads to a statistical operator; this quantum-theoretical treatment justifies the statistical and fundamental assumption of classical theory, which assumes that the lasing system is in a Glauber state. D.P.F.

#### A65-25271 \*

##### GENERATION OF A SECOND OPTICAL HARMONIC IN A LASER RESONATOR [GENERATSIYA DRUGOI OPTICHNOI GARMONIKI V REZONATORI LAZERA].

I. O. Marushko and V. S. Mashkevich (Akademiia Nauk Ukrain's'koi RSR, Institut Fiziki, Kiev, Ukrainian SSR).

*Ukrains'kii Fizicheskii Zhurnal*, vol. 10, Mar. 1965, p. 312-322.

11 refs. In Ukrainian, with summary in Russian.

Investigation, by Mashkevich's method of kinetic equations, of the generation of the basic electromagnetic field and the second harmonic in a laser resonator as two interdependent processes. The effect of the second harmonic on the laser performance and the optimum conditions for converting the fundamental frequency into the harmonic are determined. Kinetic equations for a laser with a nonlinear-crystal resonator are given, covering both high- and low-level pumping. V.Z.

#### A65-25332 \*

##### A LASER GRATING INTERFEROMETER.

James R. Sterrett, James C. Emery, and John B. Barber

(NASA, Langley Research Center, Aero-Physics Div., Hampton, Va.).

*AIAA Journal*, vol. 3, May 1965, p. 963, 964.

Description of a low-cost interferometer which is believed to be as easy to build and adjust as a schlieren system and which has been developed for fluid mechanics research. The instrument uses a small diffraction grating to combine the light on one side of the usual schlieren beam with that on the other side. Fringes form where these two light beams overlap. The reference beam is immediately adjacent to the beam in which the disturbance is placed. A schematic drawing of the instrument is shown. It is pointed out that the light beam is not divided and then recombined as is necessary for the usual interferometer using other than a laser light source. A commercial replica transmission grating with 2000 lines/in. was used in the interferometer. M.M.

#### A65-25373

##### FUNDAMENTALS OF LASER BEAM MACHINING AND DRILLING.

Clyde M. Adams, Jr. (Massachusetts Institute of Technology, Cambridge, Mass.) and Glenn A. Hardway (Applied Lasers, Inc., Stoneham, Mass.).

(Institute of Electrical and Electronics Engineers, Machine Tools Industry Conference, Hartford, Conn., Nov. 16-18, 1964.)

*IEEE Transactions on Industry and General Applications*, vol. IGA-1, Mar.-Apr. 1965, p. 90-96.

Use of the high intensity which can be obtained by focusing the pulsed energy emitted by a ruby laser as a tool for nearly forceless machining. The method can be used on any material, regardless of thermal properties, which can be evaporated without decomposition, including almost all ceramics and metals. With most substances, almost all of the material removed by laser machining leaves in the liquid state. Only a small fraction is vaporized, and the high rate of the vaporization exerts forces which expel the liquid metal. All features of laser beam machining improve with increased intensity. The higher the intensity, the less heat is resonant in the uncut material, an important consideration with materials which are sensitive to heat shock, and the more efficient the process is in terms of volume of material removed per unit of energy. The intensities which are available with the laser are high enough so that the heat-affected zone on a cut surface is too small to be detected and there is no solidified liquid film residue on the cut surface. (Author) F.R.L.

#### A65-25589 \*

##### A METHOD OF MEASURING LOSSES IN AN OPTICAL CAVITY [OB ODNOM METODE IZMERENIYA POTER' V OPTICHESKOM REZONATORE].

Iu. V. Troitskii.

*Radiotekhnika i Elektronika*, vol. 5, May 1965, p. 954-956. In Russian.

Description of a simple method of measuring the reflection coefficient of mirrors (and thereby the total losses in a cavity) on the operating wavelength of the laser in which they are used. In this method the medium in which amplification occurs is divided into two parts, the threshold transmission of an attenuator being

measured for each part separately and for both together. The amplification of a small signal in the two sections and the product of the reflection coefficients are obtained by simultaneously solving a system of three equations for the three measurement stages.

A.B.K.

**A65-25590 \***

AN OPTICAL QUANTUM OSCILLATOR WITH CYLINDRICAL MIRRORS [OPTICHESKII KVANTOVYI GENERATOR S TSILINDRICHESKIMI ZERKALAMI].

V. M. Klement'ev and Iu. D. Kolomnikov.

*Radiotekhnika i Elektronika*, vol. 5, May 1965, p. 956, 957. In Russian.

Description of a laser with a hollow-cathode discharge on an Ne-H<sub>2</sub> mixture, the laser cavity being formed by cylindrical mirrors. The generatrices of the cylinders are turned at a 90° angle to each other. With this orientation the mirror system possesses properties similar to those of a spherical-mirror system. It is said that when one of the mirrors is turned 45-50° about the tube axis the property of noncriticality with respect to tuning is preserved. Generation is said to be possible even when the generatrices of the mirrors are parallel, but then accurate tuning is required in the planes parallel to the mirrors.

A.B.K.

**A65-25591 =**

OPERATION OF AN OPTICAL QUANTUM OSCILLATOR WITH A HOLLOW-CATHODE DISCHARGE ON AN He-Ne MIXTURE [RABOTA OPTICHESKOGO KVANTOVOGO GENERATORA NA SMESI He-Ne S RAZRIADOM V POLOM KATODE].

V. P. Chebotaev and V. V. Pokasov.

*Radiotekhnika i Elektronika*, vol. 5, May 1965, p. 958-960. In Russian.

Investigation of the dependence of the power output of a hollow-cathode oscillator on the discharge conditions for four lines corresponding to 2s-2p transitions of neon, the power generation being studied in both pure neon and a mixture of neon and helium. In pure neon, all the lines corresponding to 2s-2p transitions of neon could be resolved, in particular, the 11,523 and 11,525-Å lines. The optimum pressure at which generation is observed on these four lines is found to be equal to  $5 \times 10^{-2}$  mm Hg. When helium was added to the neon, generation on the 11,143- and 11,525-Å lines disappeared at an He pressure of 0.2 mm Hg and did not reappear at any other He pressures; generation on the 11,523-Å line first decreased, then began to increase at He pressures of about 1 mm Hg, reaching a maximum at 4 to 5 mm Hg; generation on the 11,767-Å line first disappeared, then reappeared at a pressure of about 2 mm Hg, reaching a maximum at 4 to 5 mm Hg. This behavior is attributed to an increase in the population of the 2p levels of neon, both as a result of cascade transitions and as a result of an increase in the concentration of neon metastables, it being shown experimentally that this concentration increases with an increase in the helium pressure. The optimum He pressure was found to vary slightly and to lie between 4 and 5 mm Hg.

A.B.K.

**A65-25785 =**

THEORY OF SELECTIVE MULTICAVITY TRANSMISSION MASER AMPLIFIERS.

V. N. Alfeev and Iu. P. Pimenov.

*(Radiotekhnika i Elektronika*, vol. 10, Jan. 1965, p. 45-53.)

*Radio Engineering and Electronic Physics*, vol. 10, Jan. 1965, p. 36-43. 6 refs. Translation.

[For abstract see Accession no. A65-16282 07-09]

**A65-25826**

VIGNETTING TEST FOR CATADIOPTRIC SYSTEMS USING A CW LASER.

Robert M. Zoot (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

*Applied Optics*, vol. 4, June 1965, p. 755.

Brief discussion of a vignetting test for a mirror telescope which consists of reversing the direction of the light beam intercepted from a point source at infinite distance. The point source emits light

with the same effective ray-divergence angle as the convergence angle of the telescope; therefore, any obstruction to the beam will appear as a shadow in the projected clear aperture. By noting characteristics of the shadow, the obstruction can be located and corrected.

B.B.

**A65-25828**

CALCITE PRISMS AS HIGH-POWER LASER BEAM COMBINERS. Charles C. Wang and George W. Racette (Philco Corp., Applied Research Laboratory, Blue Bell, Pa.).

*Applied Optics*, vol. 4, June 1965, p. 759-761. 5 refs. USAF-supported research.

Report of collinearization of two laser beams through use of the birefringence of uniaxial crystal of calcite. It is shown that the insertion efficiency of prisms made from this material is comparable to that of dielectric-coated dichroic mirrors. The use of calcite prisms as beam combiners can probably be extended to other wavelengths where sufficient birefringence in calcite exists.

B.B.

**A65-25861**

THE LASER OSCILLATOR WITH AN EXTERNAL SIGNAL.

R. H. Pantell (Stanford University, W. W. Hansen Laboratories of Physics, Stanford, Calif.).

*IEEE, Proceedings*, vol. 53, May 1965, p. 474-477. 9 refs.

Contract No. Nonr-225(48).

Description of a laser oscillator with an externally applied signal. Calculations are made (1) to determine the conditions for quenching the natural oscillation, (2) to evaluate the frequency pulling and pushing effects, and (3) to determine the power gain at the forcing frequency.

(Author) B.B.

**A65-25872**

WIDE-BAND OPTICAL FREQUENCY TRANSLATION.

J. R. Kerr.

*IEEE, Proceedings*, vol. 53, May 1965, p. 496, 497.

Proposal of a system which will translate the frequency of a gas laser beam over a range of several Gc, using readily obtainable materials and a few watts of microwave power. The approach is said to circumvent the need for electro-optic crystals possessing cubic symmetry, which are hard to get.

B.B.

**A65-25873**

HARMONIC CROSS-RELAXATION IN CHROMIUM-DOPED RUTILE.

D. H. Paxman and G. I. Haddad (Michigan, University, Dept. of Electrical Engineering, Ann Arbor, Mich.).

*IEEE, Proceedings*, vol. 53, May 1965, p. 501, 502.

Description of experiments on chromium-doped rutile where a pump frequency of about 30 Gc was used to obtain population inversion at a signal frequency of about 40 Gc. The scheme employed utilizes harmonic cross relaxation and is similar to that used by Arams, in which ruby was used to obtain a maser at about 10.5 Gc with a pump frequency of 9.5 Gc.

B.B.

**A65-25874**

AXIAL MODES OF A RUBY LASER WITH EXTERNAL REFLECTORS.

S. Singh, R. G. Smith, and M. Di Domenico, Jr. (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

*IEEE, Proceedings*, vol. 53, May 1965, p. 507, 508. 6 refs.

Outline of the finding that the position of the ruby rod along the axis of an interferometer is important in determining whether or not oscillations of adjacent interferometer modes are present. In particular, it is found that intense simultaneous oscillation of adjacent axial modes occurs only when the ruby rod is near the end of the cavity. Strong oscillation of pairs of modes separated by more than one mode number occurs when the rod is at other positions along the axis of the cavity.

B.B.

**A65-25877**

ON THE PRODUCTION OF HIGH ENERGY PARTICLES BY GIANT-PULSE LASERS.

Walter Vali and Victor Vali (Boeing Co., Scientific Research Laboratories, Seattle, Wash.).

*IEEE, Proceedings*, vol. 53, May 1965, p. 517, 518.

Demonstration that presently available giant-pulse lasers can produce particles with energies higher than  $10^{10}$  ev. B. B.

#### A65-25885

##### LOW-LEVEL SINGLE-RESONATOR LASER AMPLIFIERS.

A. D. Jacobson and T. R. O'Meara (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

*IEEE, Proceedings*, vol. 53, May 1965, p. 529. 9 refs.

Examination of a single-resonator reflection amplifier. The analysis is formulated in terms of a scattering matrix description of an optical resonator, but an equivalent microwave maser is equally well described if a guide wavelength factor is included. Reflection amplifier gain sensitivities and stability margins have been computed with respect to both reflectivity and activity as a function of active-electrical length, reflectivity, and bandcenter gain. B. B.

#### A65-25888

##### A LIMIT UPON LASER AMPLIFIER PUMP LEVEL.

A. C. Scott (Wisconsin, University, Dept. of Electrical Engineering, Madison, Wis.).

*IEEE, Proceedings*, vol. 53, May 1965, p. 537. 7 refs.

NSF-supported research.

Investigation of an instability in a laser amplifier medium which should occur at high pumping levels, considering the "transmission-line equivalent circuit" for plane-wave propagation in a laser medium. Propagation, electric field, and magnetic field are taken as analogous to transmission-line voltage and current, respectively. B. B.

#### A65-25890

##### LASER DEFLECTION MODULATION IN A CdS PRISM.

R. Kalibjian, T. Huen, C. Maninger, and J. Yee (California, University, Lawrence Radiation Laboratory, Livermore, Calif.).

*IEEE, Proceedings*, vol. 53, May 1965, p. 539.

AEC-sponsored research.

Demonstration of deflection modulation of a Ne-He laser beam by passing current through a CdS prism with ohmic contacts. It is concluded that the deflection modulation of the laser beam is probably due to temperature changes in the CdS prism; therefore, such deflection can be used to measure the temperature of the environment in which the prism is located. In situations where thermocouple measurements present problems, there may be advantages in using thermal deflection of a laser beam. B. B.

#### A65-26003

##### A REPETITIVELY Q-SWITCHED, CONTINUOUSLY PUMPED YAG:Nd LASER.

J. E. Geusic, M. L. Hensel, and R. G. Smith (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

*Applied Physics Letters*, vol. 6, May 1, 1965, p. 175-177.

Contract No. DA-36-039-AMC-02333(E).

Description of the generation of repetitive high-power pulses by the repeated Q-switching of a continuously pumped YAG:Nd laser. The laser rod was pumped continuously with a 1000-w tungsten-iodine lamp, and the Q-switching was achieved by rapidly rotating one of the two mirrors comprising the laser resonator. When the mirror was stationary, an output at  $1.06\mu$  of 250 mw was obtained. For the same 1000-w lamp input, rotation of the mirror at speeds greater than 100 rps produced repetitive Q-switched pulses with a peak power of 250 w. The characteristic pulse growth time was 60 nanosec. The laser described should find application in optical nonlinear studies, in optical radars, and in laser welding and machining. P. K.

#### A65-26004

##### EVIDENCE FOR RADIATION TRAPPING AS A MECHANISM FOR QUENCHING AND RING-SHAPED BEAM FORMATION IN ION LASERS.

P. K. Cheo and H. G. Cooper (Bell Telephone Laboratories, Inc., Whippany, N.J.).

*Applied Physics Letters*, vol. 6, May 1, 1965, p. 177, 178. 6 refs.

Description of a mechanism which can account for observations of quenching and of the formation of ring-shaped beams in ion lasers. It is suggested that the trapping of resonance radiation between the lower laser level and the ion ground state is responsible for both these phenomena. By treating radiation trapping as a diffusion process, calculations are made which show that this mechanism can account for the observations. P. K.

#### A65-26025 \*

##### THE PART PLAYED BY MULTIPHOTON PROCESSES IN ACHIEVING MAXIMUM POWER OF A LASER [ROL' MNOGOFOTONNYKH PROTSESSOV V USTANOVLENI PREDEL'NOI MOSHCHNOSTI KVANTOVYKH GENERATOROV].

F. B. Bunkin and A. M. Prokhorov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, Apr. 1965, p. 1084-1086. In Russian.

Discussion of the mechanism of multiphoton absorption of laser electromagnetic emission within the emitting crystal. Estimates of maximum laser power are made for lasers using GaAs and ruby crystals, as derived from the internal photoeffect in the crystals. V. P.

#### A65-26026 \*

##### INTERACTION OF OSCILLATORY MODES IN A LASER [VZAIMODEISTVIE KOLEBATEL'NYKH MOD V KVANTOVOM OPTICHESKOM GENERATORE].

L. A. Ostrovskii (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorki, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, Apr. 1965, p. 1087-1096. 11 refs. In Russian.

Discussion of a laser having two resonator modes differing in the frequency of oscillations. Approximate equations for this laser model are derived. The monochromatic and two-frequency stationary modes are defined, and their stability is examined. The transient processes in the laser are studied by methods of qualitative theory. V. P.

#### A65-26039 \*

##### INTERFERENCE MIRRORS CONSISTING OF ALTERNATING LEAD-OXIDE AND CRYOLITE FILMS [INTERFERENTSIONNYE ZERKALA IZ CHEREDUUSHCHIKHSIA SLOEV OKISI SVINTSA I KRIOLITA].

Iu. V. Nabokin and N. L. Kramarenko (Akademiia Nauk Ukrainskoi SSR, Fiziko-Tekhnicheskii Institut Nizkikh Temperatur, Kharkov, Ukrainian SSR).

*Priboiy i Tekhnika Eksperimenta*, vol. 10, Mar.-Apr. 1965, p. 189, 190. In Russian.

Experimental investigation showing the possibility of replacing ZnS by PbO as the high-refractive-index component in dielectric multilayer reflective coatings (with cryolite as the low-refractive-index component) for use as laser mirrors. It is shown that PbO-cryolite coatings with high optical characteristics can be produced by standard vacuum-deposition techniques, thus eliminating the difficulties associated with the preparation of ZnS films. V. P.

#### A65-26292

##### CONTINUOUS LASER EMISSION BY DIRECT HIGH-FREQUENCY EXCITATION OF CO<sub>2</sub> AND N<sub>2</sub>O IN VIBRATIONAL TRANSITIONS OF 00<sup>0</sup><sub>1</sub>-10<sup>0</sup><sub>0</sub> AND 00<sup>0</sup><sub>1</sub>-02<sup>0</sup><sub>0</sub> [EMISSION LASER CONTINUE PAR EXCITATION HAUTE FREQUENCE DIRECTE DE CO<sub>2</sub> ET N<sub>2</sub>O DANS LES TRANSITIONS VIBRATIONNELLES 00<sup>0</sup><sub>1</sub>-10<sup>0</sup><sub>0</sub> ET 00<sup>0</sup><sub>1</sub>-02<sup>0</sup><sub>0</sub>].

Pierre Barchewitz, Lucien Dorbec, Alain Truffert, and Philippe Vautier (Paris, Université, Laboratoire d'Infrarouge, Chimie Physique, Orsay, Seine-et-Oise; Société Anonyme de Télécommunications, Laboratoire de Physique, Paris, France).

*Académie des Sciences (Paris), Comptes Rendus*, vol. 260, no. 21, May 24, 1965, p. 5491-5493. 5 refs. In French.

Experimental results, using an HF power source of approximately 100 w. It is shown that direct HF excitation of a mixture containing CO<sub>2</sub> or N<sub>2</sub>O, in addition to emitting rays of the branch P

of the transition  $00^01-10^00$  (previously described), there is a continuous emission of  $\text{CO}_2$  in the branch P of the transition  $00^01-02^00$  toward  $1045 \text{ cm}^{-1}$ , an emission in the branch R of the transition  $00^01-10^00$  for  $\text{CO}_2$  toward  $975 \text{ cm}^{-1}$ , and for  $\text{N}_2\text{O}$  toward  $955 \text{ cm}^{-1}$ . The laser power can exceed 2 w. F.R.L.

#### A65-26457

##### RAMAN SCATTERING IN SILICON.

John P. Russell (Ministry of Aviation, Royal Radar Establishment, Great Malvern, Worcs., England).

*Applied Physics Letters*, vol. 6, June 1, 1965, p. 223, 224. 8 refs.

Description of first-order Raman scattering observed in silicon using the  $6328\text{-}\text{\AA}$  output of an He-Ne gas laser. The laser output was focused on the surface of the silicon, and the back-scattered radiation analyzed. The value of the Raman shift is found to be  $523 \text{ cm}^{-1}$ , directly establishing the optic-phonon energy at the center of the Brillouin zone. The results are in excellent agreement with those deduced from IR absorption and neutron scattering experiments.

P. K.

#### A65-26582

##### DIFFRACTION OF LIGHT BY A GRATING CAUSED BY THE FARADAY OR KERR EFFECT IN THE ELECTRO-MAGNETIC FIELD OF A LASER BEAM.

R. Enderlein and W. Tausendfreund (Berlin, Universität, Institut für theoretische Physik, Berlin, East Germany).

*Physica Status Solidi*, vol. 9, May 1, 1965, p. K117-K122.

Investigation of a medium which is subjected to the electro-magnetic field of a laser beam, and which has a refractive index periodic in space and time due to the Faraday and Kerr effects. In the electromagnetic field of the laser wave, the absorption coefficient is a periodic function in space and time because of the magneto- and electro-absorption. In this case the medium represents an amplitude grating.

B. B.

#### A65-26687 \*

##### OSCILLATION THRESHOLD OF A RUBY LASER TAKING INTO ACCOUNT THE DISSIPATION OF PUMPING POWER IN THE CRYSTAL [POROG GENERATSII OPTICHESKOGO KVANTOVOGO GENERATORA NA RUBINE S UCHETOM RASSEIANIA ENERGI NAKACHKI V KRISTALLE].

D. N. Vylegzhanin and M. Kh. Zelikman.

*Radiotekhnika i Elektronika*, vol. 10, June 1965, p. 1147-1150. 6 refs. In Russian.

Derivation of a formula for two critical values of the pumping power for a solid-state laser. It is shown how using this formula makes it possible to determine the characteristics of a CW laser and a pulsed laser.

V. P.

#### A65-26694 \*

##### THEORY OF LASER RADIATION DUE TO INTERBAND TRANSITIONS IN AN EXTRINSIC SEMICONDUCTOR [TEORIYA LAZER-NOGO IZLUCHENIYA NA ZONA-ZONNYKH PEREKHODAKH V PRIMESNOM POLUPROVODNIKE].

G. Iu. Buriakovskii, V. L. Vinetskii, and V. S. Mashkevich (Akademiia Nauk Ukrainskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR).

*Fizika Tverdogo Tela*, vol. 7, Apr. 1965, p. 1028-1036. 5 refs. In Russian.

Application of the kinetic-equation method to a study of steady-state laser radiation occasioned by band-band transitions in a semiconductor containing impurity capture levels. The frequency of the fundamental mode and the positions of the Fermi levels of the electron and hole bands are determined. Both spontaneous and induced transitions are considered, and an expression is obtained for the oscillation threshold and its dependence on the impurity concentration. Intraband light absorption is neglected, but this is considered permissible at sufficiently low temperatures.

W. M. R.

#### A65-26727

##### 75-MICRON LASER.

Iu. N. Petrov and A. M. Prokhorov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(*ZHETF Pis'ma v Redaktsiiu*, vol. 1, Apr. 1, 1965.)

*JETP Letters*, vol. 1, Apr. 1, 1965, p. 24, 25. 8 refs. Translation.

Use of a gas discharge to construct a laser operating in the far IR. Emission of a  $75.5778\text{-}\mu$  wavelength was effected in the mixtures He + Xe (100:1) at optimal pressure  $p_{\text{Xe}} = 3.5 \times 10^{-2} \text{ mm Hg}$  and Kr + Xe (3:1) at  $p_{\text{Xe}} = (1.5 - 2) \times 10^{-2} \text{ mm Hg}$ . A generator was used with high-frequency discharge and with internal confocal silvered mirrors with reflection coefficients of 100 and 95%; the substrates were of crystalline quartz. The length of the discharge quartz tube was 1.80 m, and the inside diameter was 6 mm.

F. R. L.

#### A65-26819

##### JUNCTION HEATING IN GaAs INJECTION LASERS.

Karl Konnerth (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N. Y.).

*IEEE, Proceedings*, vol. 53, Apr. 1965, p. 397, 398.

Army-supported research.

Determination of the temperature rise in the junction region of a Fabry-Pérot GaAs injection laser, using three different methods which are said to give consistent results. The first technique used is time-resolved spectroscopy, the second is based on the length of time the laser stays on, and the third involves an analysis of steady-state heat flow in the laser.

A. B. K.

#### A65-26820

##### MODE SELECTION AND MODE VOLUME ENHANCEMENT IN A GAS LASER WITH INTERNAL LENS.

T. Li and P. W. Smith (Bell Telephone Laboratories, Inc., Crawford Hill Laboratory, Holmdel, N. J.).

*IEEE, Proceedings*, vol. 53, Apr. 1965, p. 399, 400. 8 refs.

Description of a method of obtaining a single-mode output and mode volume enhancement in a gas laser with an internal lens. It is shown how a visible He-Ne gas laser can be operated in the fundamental transverse mode by using a confocal configuration consisting of a pair of plane mirrors of markedly different aperture sizes placed in the two focal planes of a converging lens.

A. B. K.

#### A65-26821

##### RUBY AS A POTENTIAL MATERIAL FOR SUBMILLIMETER MASER.

J. Hermance and G. Wessel (Syracuse University, Dept. of Physics, Syracuse, N. Y.).

*IEEE, Proceedings*, vol. 53, Apr. 1965, p. 400, 401. 6 refs. Contract No. Nonr-669(18).

Investigation of the suitability of ruby as submillimeter maser material. Experiments are said to show that the transition between  $2A(^2E)$  and  $E(^2E)$  will not go into stimulated emission at high temperatures and that the relaxation time between the levels must be shorter than  $10^{-8} \text{ sec}$  at liquid-nitrogen temperature. Operation of the ruby at liquid-helium temperature is therefore regarded as a necessity. An excitation scheme which is thought to have a fair chance of success in producing the desired transition is proposed.

A. B. K.

#### A65-26828

##### NOTE ON LASER MONITORS.

S. E. Schwarz (California, University, Dept. of Electrical Engineering, Berkeley, Calif.).

*IEEE, Proceedings*, vol. 53, Apr. 1965, p. 414, 415.

Consideration of the use of photomultipliers as laser monitors. In an experiment involving two photomultipliers the outputs of which are Gaussian random variables, the mean values and standard deviations of which are assumed to be equal, it is found that the probability-density function does not approach the expected Gaussian form. It is therefore concluded that there is considerable danger in using a photomultiplier as a laser monitor. The use of a high-current photodiode is proposed instead.

A. B. K.



**A65-26860 #**

MAGNETIC Q-FACTOR OF PARAMAGNETIC MASER CRYSTALS [DOBROĆ MAGNETYCZNA MASEROWYCH KRYSZTAŁÓW PARAMAGNETYCZNYCH].

Marian Herman (Warszawa, Politechnika, Katedra Fizyki Ogólnej "B," Warsaw, Poland).

Postępy Fizyki, vol. 16, no. 2, 1965, p. 139-158. 15 refs. In Polish.

Discussion of the magnetic Q-factor,  $Q_{MS}$ , which describes the energy losses of the electromagnetic field in a maser crystal. It is shown that  $Q_{MS}$  can have a pronounced effect on the performance parameters of both a traveling-wave maser and a resonator maser, and that it depends on a variety of factors. In maser design, the  $Q_{MS}$  can be minimized by increasing the filling factor of the resonant cavity, by increasing the pumping frequency, or by increasing the spin-spin relaxation time. The average value of  $Q_{MS}$  in masers is on the order of 100. V.P.

**A65-26930**

PROGRESS IN RADIO SCIENCE 1960-1963. VOLUME 7 - RADIOELECTRONICS; PROCEEDINGS OF COMMISSION VII ON RADIOELECTRONICS DURING THE 14TH GENERAL ASSEMBLY OF URSI, TOKYO, JAPAN SEPTEMBER 15-20, 1963.

Edited by R. E. Burgess (British Columbia, University, Dept. of Physics, Vancouver, Canada).

Amsterdam, Elsevier Publishing Co., 1965. 168 p. \$11.00.

## CONTENTS:

PLASMAS - GEOPHYSICAL AND ASTROPHYSICAL SCALE. Reimar Lüdt (Max-Planck-Institut für Physik und Astrophysik, Munich, West Germany), p. 8-20. [See A65-26931 16-30]

PLASMAS - LABORATORY SCALE. Bo Lehnert (Royal Institute of Technology, Stockholm, Sweden), p. 27-89. 185 refs. [See A65-26932 16-25]

OPTICAL MASER PRINCIPLES. A. Javan (Massachusetts Institute of Technology, Cambridge, Mass.), p. 97-106. 15 refs. [See A65-26933 16-16]

THE ATOMIC HYDROGEN MASER. Norman F. Ramsey (Harvard University, Cambridge, Mass.), p. 111-127. 21 refs. [See A65-26934 16-16]

ON THE APPLICATIONS OF MICROWAVE AND OPTICAL MASERS. H. E. D. Scovil (Bell Telephone Laboratories, Inc., Murray Hill, N.J.), p. 129-157. 37 refs. [See A65-26935 16-16]

BEAM NOISE MEASUREMENT BY LASER. S. Saito and Y. Fujii (Tokyo, University, Tokyo, Japan), p. 160-164. [See A65-26936 16-16]

AUTHOR INDEX, p. 168.

**A65-26933**

OPTICAL MASER PRINCIPLES.

A. Javan (Massachusetts Institute of Technology, Physics Dept., Cambridge, Mass.).

IN: PROGRESS IN RADIO SCIENCE 1960-1963. VOLUME 7 - RADIOELECTRONICS; PROCEEDINGS OF COMMISSION VII ON RADIOELECTRONICS DURING THE 14TH GENERAL ASSEMBLY OF URSI, TOKYO, JAPAN, SEPTEMBER 15-20, 1963. [A65-26930 16-16]

Edited by R. E. Burgess.

Amsterdam, Elsevier Publishing Co., 1965, p. 97-106. 15 refs.

Discussion of some of the physical principles underlying the operation of lasers and their utilizations in the study of the interaction of radiation and matter. Generally, a laser consists of an atomic system with an inverted population distribution within at least two of its energy levels. If an optical transition is allowed between the two levels, the process of stimulated emission of radiation leads to an amplification of electromagnetic radiation at frequencies within the linewidth of the corresponding transition. The coupling of this system with normal modes of an optical resonator results in excitation of those resonator modes which present sufficiently high Q-values at frequencies within the width of the amplifying atomic transition. Pulsed and continuous-operation lasers are discussed, and their different fields of application are described. S.H.B.

**A65-26934**

THE ATOMIC HYDROGEN MASER.

Norman F. Ramsey (Harvard University, Lyman Laboratory of Physics, Cambridge, Mass.).

IN: PROGRESS IN RADIO SCIENCE 1960-1963. VOLUME 7 - RADIOELECTRONICS; PROCEEDINGS OF COMMISSION VII ON RADIOELECTRONICS DURING THE 14TH GENERAL ASSEMBLY OF URSI, TOKYO, JAPAN, SEPTEMBER 15-20, 1963. [A65-26930 16-16]

Edited by R. E. Burgess.

Amsterdam, Elsevier Publishing Co., 1965, p. 111-127. 21 refs.

Discussion of several experiments with an atomic hydrogen maser that were performed in an effort to obtain a device that would measure rf and microwave spectral lines with high precision. In this device, hydrogen atoms of the upper hyperfine state are focused on the entrance aperture of a Teflon-coated quartz bulb in which the atoms are stored for approximately 1 sec. The bulb is surrounded by a cylindrical rf cavity, and when the cavity is tuned to the hyperfine frequency of atomic hydrogen, maser radiation is produced. The radiation has high-frequency stability due to the large Q-value of the line. Results of the theoretical calculations for the threshold flux of atoms required for maser oscillations are given, and several such measurements as hyperfine separations and spin-exchange cross sections are discussed. S.H.B.

**A65-26935**

ON THE APPLICATIONS OF MICROWAVE AND OPTICAL MASERS.

H. E. D. Scovil (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

IN: PROGRESS IN RADIO SCIENCE 1960-1963. VOLUME 7 - RADIOELECTRONICS; PROCEEDINGS OF COMMISSION VII ON RADIOELECTRONICS DURING THE 14TH GENERAL ASSEMBLY OF URSI, TOKYO, JAPAN, SEPTEMBER 15-20, 1963. [A65-26930 16-16]

Edited by R. E. Burgess.

Amsterdam, Elsevier Publishing Co., 1965, p. 129-157. 37 refs.

Discussion of the general properties of maser circuits, including the radiation field and maser media. Unlike conventional amplifiers, the maser contains a very large number of individual or molecular amplification centers acting essentially independently. The emphasis is placed on the engineering problems encountered as a result of this unique feature of masers. Systems applications for the maser and the role of the laser are also discussed. S.H.B.

**A65-26936**

BEAM NOISE MEASUREMENT BY LASER.

S. Saito and Y. Fujii (Tokyo, University, Institute of Industrial Science, Tokyo, Japan).

IN: PROGRESS IN RADIO SCIENCE 1960-1963. VOLUME 7 - RADIOELECTRONICS; PROCEEDINGS OF COMMISSION VII ON RADIOELECTRONICS DURING THE 14TH GENERAL ASSEMBLY OF URSI, TOKYO, JAPAN, SEPTEMBER 15-20, 1963. [A65-26930 16-16]

Edited by R. E. Burgess.

Amsterdam, Elsevier Publishing Co., 1965, p. 160-164.

Discussion of a method for determining the noise behavior of the potential minimum of traveling-wave tubes and the reduction factor for the shot noise at this value. The method employs the photoelectron emission which is coincident with the thermal emission from the oxide-coated cathode of the tube. The modulated output of a ruby laser is used to stimulate emission from the cathode. The potential minimum which occurs in the vicinity of the cathode reduces the shot noise and the demodulated components of the photoelectrons. If these can be treated as a small perturbation and both show similar behavior at or near the potential minimum, the reduction factors for both can be expected to be the same. Thus, the reduction factor of the shot noise can be obtained by observing the demodulated components of the photoelectrons. S.H.B.

**A65-26946**

OPTICAL AMPLIFICATION OF THE APPARENT RATE OF ROTATION OF A REFLECTOR IN Q-SWITCHING A LASER RESONATOR.

J. W. Gates and R. G. N. Hall (National Physical Laboratory, Teddington, Middx., England).  
Nature, vol. 206, June 12, 1965, p. 1141.

Description of an optical arrangement for increasing the rate of Q-switching in a laser without introducing additional optical components or increasing the number of reflecting and transmitting surfaces. An afocal system of magnification M is introduced between the ruby rod and the rotating roof prism of a typical Q-switched laser. The aperture of the prism filled by the beam is thus increased by a factor of M, and the rate of angular sweep of the reflected beam across the fixed reflector is increased by the same factor, giving an improvement in Q-switching. A means of realizing this scheme without having to introduce a separate afocal system is described. The given arrangement increases the speed of switching, reduces the peak power density in the reflecting prism, and makes the competing non-Q-switched resonant structure much more lossy and less likely to sustain oscillation.

P. K.

#### A65-26933

##### NEW LINES IN A PULSED XENON LASER.

John A. Dahlquist (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Research Laboratories, Palo Alto, Calif.).  
Applied Physics Letters, vol. 6, May 15, 1965, p. 193, 194.  
 7 refs.

Research supported by the Lockheed Independent Research Program.

Account of the observation of nine additional laser lines in a pulsed xenon discharge under conditions which do not produce any of the 18 lines of the Xe II spectrum which have been reported in recent publications. The two plasma tubes used each had a discharge length of about 1 m; one tube had a 5 mm-bore and cold nickel cathode; the other had a 6-mm-bore and a molybdenum cathode. Laser action occurred over a narrow pressure range of from about 0.5 to 3 mtorr.

B. B.

#### A65-26954

##### DERIVATION OF A FREQUENCY-SENSITIVE SIGNAL FROM A GAS LASER IN AN AXIAL MAGNETIC FIELD.

Irwin Tobias (Rutgers University, School of Chemistry, New Brunswick, N. J.), Michael L. Skolnick, Robert A. Wallace, and Thomas G. Polanyi (Laser, Inc., Briarcliff Manor, N. Y.).  
Applied Physics Letters, vol. 6, May 15, 1965, p. 198-200.  
 12 refs.

Theoretical and experimental investigation of an effect which may form the basis of a scheme to increase the frequency stability of lasers. A gas laser with internal optics, operating in a single mode and placed in an axial magnetic field, is considered. Under the influence of the magnetic field, the active medium acquires a negative circular dichroism; therefore the intensity of the left-circularly-polarized output of the laser differs from the intensity of the right-circularly-polarized output, and only when the two have their frequencies symmetrically disposed about the line center will their intensities be equal. This is the effect which is studied.

B. B.

#### A65-26955

##### ENERGY TRANSFER AND CW LASER ACTION IN $Tm^{3+}:Er_2O_3$ .

B. H. Soffer and R. H. Hoskins (Korad Corp., Santa Monica, Calif.).  
Applied Physics Letters, vol. 6, May 15, 1965, p. 200, 201.  
 Contract No. AF 33(615)-1967.

Discussion of the successful pulsed and CW laser operation of  $Er_2O_3:Tm^{3+}$  at  $5169\text{ cm}^{-1}$  ( $1.934\mu$ ) at  $77^\circ K$ . This is the first laser material in which the host material itself provides the dominant pumping mechanism by means of energy transfer. The laser experiments were conducted with a sample about 1 cm in length with flat and parallel silvered ends using a fast gold-doped germanium detector. CW operation was observed using 500-watt quartz-iodine tungsten lamps as the pumping source.

B. B.

#### A65-26956

##### ZEEMAN EFFECT, FREQUENCY PULLING AND FREQUENCY PUSHING IN A SINGLE-MODE He-Ne LASER.

P. T. Bolwijn (Utrecht, State University, Physics Laboratory, Utrecht, Netherlands).

Applied Physics Letters, vol. 6, May 15, 1965, p. 203, 204.  
 9 refs.

Description and interpretation of the influence of interferometer tuning on the frequency of the beat between the two Zeeman components in the radiation of an He-Ne laser with applied axial magnetic fields of from 5 to 30 oe. Circularly polarized fields were observed, and a dc-excited short planar He-Ne laser operating in a single axial mode at  $1.153\mu$  wavelength was used. The total gas pressure was about 5 torr. The strong dependence of beat frequency on interferometer tuning is shown in an included graph.

B. B.

#### A65-26958

##### MULTIMODE EFFECTS IN THE GAIN OF RAMAN AMPLIFIERS AND OSCILLATORS. I - OSCILLATORS.

P. Lallemand (Harvard University, Div. of Engineering and Applied Physics, Gordon McKay Laboratory, Cambridge, Mass.) and N. Bloembergen (California, University, Dept. of Electrical Engineering and Dept. of Physics, Berkeley, Calif.).  
Applied Physics Letters, vol. 6, May 15, 1965, p. 210-212.  
 6 refs.

Navy-supported research.

Brief discussion of the multimode effects of the laser beam as a hindrance to interpretation of the quantitative measurements on the Raman gain. It is found that the gain per unit length in a Raman cell may vary by a factor of five or more; the behavior of Raman oscillators is also strongly affected by the mode structure of the exciting laser beam.

B. B.

#### A65-27064

##### EVOLUTION IN TIME OF THE DISCHARGES INDUCED IN GASES BY A LASER [EVOLUTION TEMPORELLE DES DECHARGES INDUITES DANS LES GAZ PAR UN LASER].

Claude Breton, Maurice Capet, Vincent Chalmeton, Dong Nguyen Quang, and Renaud Papoulet (EURATOM-Commissariat à l'Energie Atomique, Groupe de Recherches sur la Fusion, Fontenay-aux-Roses, Seine, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 260, no. 22, May 31, 1965, p. 5731-5734. In French.

Description of experiments which make it possible to clarify the concepts of threshold and breakdown, to measure the characteristics of the emitted light, and to demonstrate the nonlinear nature of the light-discharge interaction. The experiments were conducted in air, nitrogen, and helium gas under pressures ranging from 1 to 25 atm, using a laser triggered by neodymium glass and a rotating prism. The laser pulse, in the shape of a half-sinusoid with a duration of about 90 nsec, had an energy content of 1 joule. The nominal frequency was  $3 \times 10^{14}$  cps. It is shown that the beam-gas interaction is quite strong well before the threshold value is attained and that the variations in emission and transmission are retarded in proportion to increasing gas pressure and decreasing laser energy.

D. P. F.

#### A65-27092

##### ELECTROMAGNETIC FIELD IN THE NEIGHBORHOOD OF THE FOCUS OF A COHERENT BEAM.

A. Boivin (Laval University, Dept. of Physics, Quebec, Canada) and E. Wolf (Rochester, University, Dept. of Physics and Astronomy, Rochester, N. Y.).

Physical Review, 2nd Series, Section B, vol. 138, June 21, 1965, p. B 1561-B 1565. 10 refs.  
 Army-supported research.

Analysis of the typical structure of the focal region of a coherent light beam that emerges from an aplanatic optical system by an integral representation for the electromagnetic field in such a region of focus, as derived by Ignatowsky (1919) and by Richards and Wolf (1959). Contours of the time-averaged electric energy density in the focal plane, in one defocused plane and in two meridional sections of the focal region of a system with angular semiaperture  $45^\circ$ , are presented. The meridional diagrams refer to axial sections through a cylindrical region around the axis near focus, of length  $16\lambda$  and cross-sectional diameter  $10\lambda$ , where  $\lambda$  is the wavelength of the light.

## A65-27148

It is found that the field has a strong longitudinal component at certain points of the focal plane and that longitudinal electric field strengths of the order of  $10^5$  v/cm could now be attained with focused laser beams. A diagram illustrating the complete behavior of the longitudinal component in the focal plane is also given.

(Author) D. P. F.

## A65-27148 \*

A PLANE-PARALLEL GLASS PLATE IN THE CAVITY OF AN OPTICAL MASER.

Iu. D. Kolomnikov, Iu. V. Troitskii, and V. P. Chebotaev. (*Radiotekhnika i Elektronika*, vol. 10, Feb. 1965, p. 370, 371.) *Radio Engineering and Electronic Physics*, vol. 10, Feb. 1965, p. 312-314. Translation.

[For abstract see Accession no. A65-18555 08-16]

## A65-27149 \*

OPERATING CONDITION OF AN OPTICAL MASER CONTAINING A HELIUM-NEON MIXTURE.

V. P. Chebotaev. (*Radiotekhnika i Elektronika*, vol. 10, Feb. 1965, p. 372, 373.) *Radio Engineering and Electronic Physics*, vol. 10, Feb. 1965, p. 314-316. Translation.

[For abstract see Accession no. A65-18556 08-16]

## A65-27150 \*

EFFECT OF HYDROGEN AND OXYGEN ON THE OPERATION OF A NEON MASER.

V. P. Chebotaev. (*Radiotekhnika i Elektronika*, vol. 10, Feb. 1965, p. 374-376.) *Radio Engineering and Electronic Physics*, vol. 10, Feb. 1965, p. 316-318. 9 refs. Translation.

[For abstract see Accession no. A65-18557 08-16]

## A65-27151 \*

OPERATING CONDITIONS OF AN OPTICAL MASER WITH A HELIUM-XENON MIXTURE, IN THE MIDDLE INFRARED REGION OF THE SPECTRUM.

A. A. Kuznetsov and D. I. Mash (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). (*Radiotekhnika i Elektronika*, vol. 10, Feb. 1965, p. 376, 377.) *Radio Engineering and Electronic Physics*, vol. 10, Feb. 1965, p. 319-322. 9 refs. Translation.

[For abstract see Accession no. A65-18558 08-16]

## A65-27196

LENSELESS PHOTOGRAPHY.

George W. Stroke (Michigan, University, Electro-Optical Sciences Dept., Ann Arbor, Mich.). *International Science and Technology*, May 1965, p. 52-56, 58, 60.

Description of a new technique for making lensless photographs based on the use of holograms and laser light beams. A hologram is an interference pattern between a reference wave and the waves scattered by the object being recorded. The reference wave is supplied by a laser beam; in essence the plane wave from the laser acts as a sort of carrier wave which is modulated by the signal from the object. This signal is separated from the carrier by comparing it with an unmodulated wave and it is this signal which is then recorded on a transparent photographic plate (without having to use a camera). Holograms record not only the brightness at a certain point in a scene, but also the position of the point in depth. The hologram, in the form of a transparency, is held in the beam of a laser and an observer looking through the hologram toward the laser is then able to see the original scene exactly as it appeared when photographed. The reconstruction of the scene from the hologram is a diffraction process. Very high-degree magnification is possible because the effect of simple geometric magnification is added to the magnification occurring when a longer wavelength is used upon viewing the hologram than was used in making it; viewing with a longer wavelength changes the hologram's effective focal length. It is expected that magnifications of the order of a million

will be possible with the combined effect of these two processes. This new technique appears to hold great promise when applied to the field of X-ray microscopy.

D. P. F.

## A65-27328

PROBLEM OF MODE DEFORMATION IN OPTICAL MASERS.

H. Statz and C. L. Tang (Raytheon Co., Research Div., Waltham, Mass.).

*Journal of Applied Physics*, vol. 36, June 1965, p. 1816-1819. 7 refs. Contract No. AF 19(628)-3862.

Investigation of laser mode deformation due to nonuniformities in gain saturation. Through numerical solutions it is found that even with nonuniform gain distribution in the transverse direction, the lower-order optical modes as originally calculated represent the electromagnetic fields in the cavity rather accurately. Earlier calculations of the number of oscillating off-axis modes in lasers are justified.

(Author) A. B. K.

## A65-27334

ULTRAVIOLET ION LASER TRANSITIONS BETWEEN 2300 AND 4000 Å.

P. K. Cheo and H. G. Cooper (Bell Telephone Laboratories, Inc., Whippany, N.J.).

*Journal of Applied Physics*, vol. 36, June 1965, p. 1862-1865. 17 refs.

Observation of fifty-five ultraviolet laser transitions in ionized N, O, Ne, Ar, Kr, and Xe in the 2300- to 4000-Å wavelength region. The electron transition is p-s for all identified lines, with the exception of two xenon transitions which are p-d. Threshold currents for laser action in a 4-mm-bore tube were in the ranges 10-100, 100-500, and > 400 Å, respectively, for singly, doubly, and triply ionized atoms. Both current saturation and current quenching of laser action were observed. Results with two tube bores show that the usual inverse relation between gain and tube diameter does not hold in ultraviolet ion lasers.

(Author) A. B. K.

## A65-27427 \*

THE INTERACTION OF LASER BEAMS WITH METALS.

Carl M. Verber and Albert H. Adelman (Battelle Memorial Institute, Columbus, Ohio).

*Battelle Technical Review*, vol. 14, July 1965, p. 3-8. 10 refs. Grant No. AF AFOSR 640-64.

Discussion of research concerned with the mechanisms and immediate results of the laser-metal interaction. Three types of interaction between light and metals are considered: thermal effects, multiple photon effects, and electric field effects. The first type depends on the energy content of the light beam and involves the conversion of this energy to heat at or near the metal surface. The second relies on the description of light as a beam of photons and produces effects that arise from the quantum nature of light. The third type of interaction involves effects that are due to the electromagnetic field associated with the light beam. Properties of three types of laser systems are tabulated.

B.B.

## A65-27533 \*

QUALITY MODULATION OF A NEODYMIUM-GLASS LASER WITH THE HELP OF A PASSIVE SHUTTER [MODULIATSIA DOBROT-NOSTI LAZERA NA NEODIMOVOM STEKLE S POMOSHCH'U PASSIVNOGO ZATVORA].

V. I. Malyshev, A. S. Markin, and V. S. Petrov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*ZHETF Pis'ma v Redaktsiiu*, vol. 1, May 1, 1965, p. 49-52. In Russian.

Brief description of research on the Q-switching of an Nd laser by using a polymethine dye in a methyl alcohol solvent. A rod of Nd-activated glass (120 mm long, 12 mm in diam.) was used in conjunction with a dielectric plane mirror with a reflection coefficient of 98% and a cuvette (3 mm in radius) containing the dye solution. Switching times between 1 and 10 nsec were achieved.

R. A. F.

**A65-27354****PRODUCTION OF GIANT LASER EMISSION PULSES IN NEODYMIUM ACTIVATED GLASS WITH THE AID OF TRANSLUCENT SOLUTIONS.**

O. L. Lebedev, V. N. Gavrilov, Iu. M. Griaznov, and A. A. Chastov.

(ZHETF Pis'ma v Redaktsiiu, vol. 1, Apr. 15, 1965.)

JETP Letters, vol. 1, Apr. 15, 1965, p. 47, 48. 6 refs. Translation.

Production of giant pulses in an Nd laser by varying the cavity Q with a quinoline solution of the polymethine dye, 1,9-di(N-methyl-quinoline-4)-5-acetoxynonemethineperchlorate. Depending on the solvent, the absorption maximum ranges from 1.03 to 1.09  $\mu$ . A rod of glass activated with neodymium (120 mm long, 10 mm in diam.) was employed with external dielectric mirrors having reflection coefficients of 68 and 90%. In the free-lasing mode, at a pump energy on the order of 2000 joules, the output power was 4 joules.

W.M.R.

**A65-27602****PROPERTIES OF THE PbSe DIODE LASER.**

J. F. Butler, R. H. Rediker (Massachusetts Institute of Technology, Lincoln Laboratory, Applied Solid-State Physics Group, Lexington, Mass.), and A. R. Calawa (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).

IEEE Journal of Quantum Electronics, vol. QE-1, Apr. 1965,

p. 4-7. 16 refs.

Observation of diode laser action at 8.5  $\mu$  with PbSe. This laser is of potential interest for terrestrial communications since its emission is in the 8- to 14- $\mu$  atmospheric window, a spectral region of high atmospheric transparency where attenuation due to scattering by haze is low. Fabrication techniques are described which are based on controlling carrier type and concentration by adjusting the Pb:Se ratio. Below threshold for laser action, the emission exhibits two spectral peaks, one near 8.5  $\mu$  which increases superlinearly with current and another near 10.1  $\mu$  which increases slowly with current. Laser action associated with the 8.5  $\mu$  peak is observed above a threshold current density of 2000 amp/cm<sup>2</sup>. From measurements which did not resolve the cavity mode structure, the emission peak was found to shift to higher energies in a [100] oriented magnetic field at the rate of  $7.1 \times 10^{-8}$  eV/gauss, or 17 Mc/gauss. This is the expected shift if the emission is associated with band-to-band transitions. The threshold current decreased to a fraction of its zero field value in a magnetic field of approximately 10 kgauss, then increased slowly with higher fields.

(Author) F.R.L.

**A65-27603****CHARACTERISTICS OF MODE-COUPLED LASERS.**

M. H. Crowell (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

IEEE Journal of Quantum Electronics, vol. QE-1, Apr. 1965,

p. 12-20. 12 refs.

Theoretical and experimental investigation of the effects of mode-coupling in a gas laser resulting from a time-varying loss within the optical cavity or from the nonlinear characteristics of the inverted population. The dominant effect resulting from this mode-coupling is that the laser operates as a pulse regenerative oscillator which produces a periodic train of subnanosecond pulses. The exact repetition frequency is determined by the frequency of the time-varying loss, which must always be set close to a multiple of  $c/2L$  - i.e., the axial mode spacing - to produce sufficient coupling. To produce pulsing without a time-varying loss, it is necessary that the Q or loss of the cavity be judiciously adjusted. In this case the repetition frequency is very close to the axial mode spacing. A preliminary experimental investigation has verified the salient features of the analysis. The measured widths of the pulses from a 6328-Å He-Ne laser and from a 4880-Å argon-ion laser were 0.5 and 0.25 nsec, respectively.

(Author) F.R.L.

**A65-27604****PERFORMANCE OF LASER-PUMPED QUANTUM COUNTERS.**

William F. Krupke (Aerospace Corp., Quantum Electronics Dept., Electronics Research Laboratory, El Segundo, Calif.).

IEEE Journal of Quantum Electronics, vol. QE-1, Apr. 1965,

p. 20-28. 25 refs.

Contract No. AF 04(695)-269.

Analysis of narrow-band quantum counters with less than unit internal quantum efficiency. The pump-power dependent expressions for the transient and steady-state quantum efficiencies are derived. These quantities are discussed for "typical" trivalent and divalent rare-earth-doped insulator crystals, and the performance of two specific systems is presented. It is shown that to achieve high quantum efficiency in trivalent rare-earth-doped quantum counter systems, the pump source must have a spectral character very different from a blackbody - i.e., it must be a laser which is resonant with the transition between the relevant excited states. Performance-limiting factors for laser-pumped quantum counters are pointed out.

(Author) F.R.L.

**A65-27607****DESCRIPTIVE THEORY OF SPIKING PULSES IN OPTICALLY PUMPED LASERS.**

Earl L. Steele (North American Aviation, Inc., Autonetics Div., Anaheim, Calif.).

IEEE Journal of Quantum Electronics, vol. QE-1, Apr. 1965,

p. 42-49.

Description of a model and provision of the mathematical formulation for describing the spike pulsing phenomenon observed in optically pumped three-level lasers. The model is based on the pumping of electrons from a ground state to an excited pump band from which they relax very rapidly to the excited laser level. With population inversion then achieved, laser action starts and repetitive pulses with decreasing amplitude are generated; the pulses then damp out and the laser output reaches a steady state as long as sufficient pump radiation energy is available. The equations describing the system in terms of the population inversion and photon density are nonlinear. However, approximations are made which permit the required relations between the transition rates to be established for such action to progress. The time variation of the population inversion and the photon density at the laser frequency are obtained for both the pumping time interval and the stimulated emission laser region.

(Author) F.R.L.

**A65-27610****STUDY OF THE OUTPUT SPECTRA OF RUBY LASERS.**

V. Evtuhov and J. K. Neeland (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

IEEE Journal of Quantum Electronics, vol. QE-1, Apr. 1965,

p. 7-12. 32 refs.

Contract No. AF 33(657)-11650.

Measurement of the frequency separation between transverse modes of a ruby laser, using a Fabry-Pérot interferometer and a high-speed camera. The results are compared with the theoretical predictions based on the curved-reflector theory. Satisfactory agreement is obtained. The measurements are verified by studying the output of the laser after application of transverse mode selection. The mode-selection technique is based on the control of the reflector size and results in single-transverse-mode operation at high pumping levels. The time dependence of the longitudinal mode spectrum of a single-transverse mode laser is studied. Very orderly mode-hopping sequences from shorter to longer wavelengths are observed. The spectrum of a relatively high-output laser which shows some regular pulsations is similarly examined. The spectrum shows interesting features, which include a near continuum during regular pulsations and repetitive shifts of the high-intensity portion of the spectrum from short to long wavelengths.

(Author) F.R.L.

**A65-27724****EFFECT OF GAUSSIAN BEAM SPREAD ON PHASE VELOCITY MATCHING IN CW OPTICAL SECOND-HARMONIC GENERATION.**

G. E. Francois and A. E. Siegman (Stanford University, Microwave Laboratory and Dept. of Electrical Engineering, Stanford, Calif.).

Physical Review, 2nd Series, Section A, vol. 139, July 5, 1965,

p. A4-A9. 5 refs.

Contract No. AF 33(657)-11144; Grant No. AF AFOSR 323-63.

Experimental and theoretical study of the angular variation of optical second-harmonic generation in ammonium dihydrogen phosphate using a Gaussian single-transverse-mode cw gas-laser beam. The observed angular dependence of the second-harmonic output near the phase matching angle is significantly different from the  $[(\sin \phi)/\phi]^2$  angular dependence predicted by plane-wave theory. The difference can be quantitatively explained by an extended analysis

which takes into account the Gaussian amplitude distribution and spherical wavefront of the cw laser beam. The theory predicts small but significant corrections to the results of measurements of the nonlinear coefficients of materials. These corrections can also account, at least approximately, for the effects of small crystal defects and imperfectly Gaussian beam patterns. (Author) D. P. F.

**A65-27725****COHERENCE IN A MODEL OF INTERACTING RADIATION AND MATTER.**

R. H. Picard and C. R. Willis (Boston University, Boston, Mass.). Physical Review, 2nd Series, Section A, vol. 139, July 5, 1965, p. A10-A15. 18 refs.  
Contract No. AF 19(628)-2460.

Preliminary results of a theoretical investigation of the origin of laser coherence properties. A model consisting of  $N$  two-level atoms in a perfect cavity interacting through their dipole moments with a single mode of the radiation field is adopted, and the resulting many-body problem is made solvable through the introduction of the self-consistent-field approximation (SCFA). It is shown that the SCFA is consistent with Glauber's suggestion that an ideal laser might be in a "coherent state," or pure eigenstate of the positive-frequency part of the electric-field operator. A conservation law is derived which assures the positive definiteness of the field-density operator, and it is shown that Glauber's coherent state is that solution of the SCFA equations which minimizes the corresponding constant of the motion. When the SCFA is modified by the introduction of particle-field correlations, the conservation law is destroyed, and the coherent state is no longer an allowed solution.

(Author) D. P. F.

**A65-27738 #****KINETIC PROCESSES IN THE GAS LASER [KINETICHESKIE PROTSESSY V GAZOVOM LAZERE].**

E. M. Belenov and A. N. Oraevskii. Optika i Spektroskopiia, vol. 18, May 1965, p. 858-865. 25 refs. In Russian.

Consideration of the kinetic processes in the plasma of a neon-helium laser. Analysis of these processes leads to the creation of a population inversion of the transition  $2p^24s^1P_1 - 2p^23p^3P_2$ . The relationship of the power output to the discharge-tube diameter and the pumping power is determined.

R. A. F.

**A65-27739 #****EXPERIMENTAL INVESTIGATION OF BEAM DIVERGENCE IN A NEON-HELIUM LASER (WAVELENGTH  $\lambda = 0.63 \mu$ ) [EKSPERIMENTAL'NOE ISSLEDOVANIIE RASKHODIMOSTI LUCHA OPTICHESKOGO KVANTOVOGO GENERATORA NA SMESI NEON-GELII (VOLNA  $\lambda = 0.63 \text{ MK}$ )].**

D. I. Mash, V. F. Papulovskii, and L. P. Chirina. Optika i Spektroskopiia, vol. 18, May 1965, p. 866-869. In Russian.

Discussion of an experiment to measure the angle of divergence  $\Theta$ , of a beam of single-mode light, type TEM<sub>00</sub>, emitted by a neon-helium laser with a wavelength of  $0.63 \mu$ . Two methods were used - a confocal arrangement with a tube 160 cm in length and two mirrors with radii of curvature 184 cm, and a nonfocal system. Using the confocal system and the formulas of Boyd and Gordon,  $\Theta$  was determined to be  $2.2^\circ$ . With the nonfocal arrangement, and related formulas,  $\Theta$  was found to be  $3.5^\circ$ . Possible sources of error in both experiment and calculation are discussed.

R. A. F.

**A65-27759****DISTRIBUTION- AND CORRELATION-FUNCTIONS FOR A LASER AMPLITUDE.**

H. Riiken (Stuttgart, Technische Hochschule, Institut für theoretische und angewandte Physik, Stuttgart, West Germany).

Zeitschrift für Physik, vol. 186, no. 1, 1965, p. 85-98. 18 refs. Research supported by the Deutsche Forschungsgemeinschaft.

Contribution to the nonlinear theory of laser noise. The lasing field is treated as a classical random variable; the noise is introduced by the concept of fluctuating dipoles. In order to determine the correlation functions, the method of distribution functions is employed; the distribution functions themselves are calculated by the Fokker-Planck equation. This procedure has the advantage that once the distribution function is known, all properties of the lasing

field - such as expectation values and correlation functions - can be obtained by simple integrations as described in detail.

(Author) D. P. F.

**A65-27772 #****DYNAMICS OF A LASER WITH TWO TYPES OF OSCILLATION [DINAMIKA OPTICHESKOGO KVANTOVOGO GENERATORA S DVUMIA TIPAMI KOLEBANII].**

N. G. Basov, V. N. Morozov, and A. N. Oraevskii (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Akademiia Nauk SSSR, Doklady, vol. 162, June 1, 1965, p. 781-784. 9 refs. In Russian.

Analysis of the time-dependence of laser modes of operation, using a laser model having two types of oscillation. The discussion leads to a solution of the difficult problem of describing the polarization of a substance under the effect of two types of oscillation. The time-dependence of laser radiation intensity in the instability region of the harmonic mode is established, as are the conditions for the regular nonattenuated fluctuations in laser radiation intensity. The latter are seen to explain some of the modes of operation observed experimentally.

V. P.

**A65-27944****RAMAN DIFFUSION OF DIFFERENT LIQUIDS IN THE DIRECTION OF THE EXCITING LIGHT [DIFFUSION RAMAN DE DIFFERENTS LIQUIDES DANS LA DIRECTION DE LA LUMIERE EXCITATRICE].**

Georges Bret (Compagnie Générale de Télégraphie sans Fil, Laboratoire, Orsay, Seine-et-Oise, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 260, no. 24, June 14, 1965, p. 6323-6326. 10 refs. In French.

Study of Raman diffusion of liquids placed outside an optical cavity and excited by a ruby laser. The liquids emit in a small solid angle which contains the direction of the incident beam of the spontaneous Raman light. The intensity of the incident beam remains proportional to the intensity of the laser light up to the threshold of stimulated emission. This threshold depends on the wave structure of the laser beam and is defined by a Raman emission which is always very intense compared to the spontaneous Raman emission. These measurements make it possible to evaluate the effective selection of Raman diffusion and the intensity of Raman light in photons per wave at the threshold of stimulated emission.

F. R. L.

**A65-28005****PHOTOMIXING WITH DIFFUSELY REFLECTED LIGHT.**

G. A. Massey (Sylvania Electric Products, Inc., Sylvania Electronic Systems Div., Electronic Defense Laboratories, Mountain View, Calif.).

Applied Optics, vol. 4, July 1965, p. 781-784.

Account of a method for estimating the sensitivity of a coherent optical heterodyne receiver in detecting laser radiation reflected from a diffuse surface. A configuration typical of many optical radar applications is considered, and the effects of transmitter beam size, receiver aperture, and heterodyne field of view on the beat-frequency signal are calculated. Two idealized surface models are used in the analysis. It is shown that the size of the scattering reflector elements in the surface can affect the optimum set of receiver parameters. The range of values of these parameters for most efficient detection is derived for both surface types and a given transmitter beam angle. The advantage of a receiver with large aperture and field of view equal to the transmitted beam width is demonstrated, and the magnitudes of errors introduced by the simplifying approximations are discussed.

(Author) B. B.

**A65-28013****E-LEVEL POPULATION OF RUBY VS PUMPING.**

V. Daneu, C. A. Sacchi, and O. Svelto (Milano, Politecnico, Istituto di Fisica, Milan, Italy).

Applied Optics, vol. 4, July 1965, p. 863-866. 18 refs.

Research supported by the Consiglio Nazionale delle Ricerche.

Experimental measurement of the E-level population of a cylindrical ruby rod as a function of the pump energy at two points of the cross section of the rod - the center and the periphery. The measurement is performed by measuring the fluorescent energy emitted after pumping by the points considered. The rod is pumped by a spiral flashtube. It is found that the experimental data of population

vs pumping follow exponential curves as expected theoretically. From these curves the pump energy necessary for equalizing the populations between ground state and laser level is obtained. The knowledge of this quantity leads to the measure of the losses (scattering plus diffraction) per pass in the rod. A value of ~45% of losses is obtained for the rod. (Author) B. B.

#### A65-28016

##### COHERENCE IN LONG-RANGE LASER BEAMS.

Harald W. Straub (U. S. Coast and Geodetic Survey, Washington Science Center, Rockville, Md.). (National Bureau of Standards, Conference on Atmospheric Limitations to Optical Propagation, Boulder, Colo., Mar. 18, 19, 1965, Paper.)

Applied Optics, vol. 4, July 1965, p. 875, 876. 5 refs.

Formulation of certain rules for the dimensions of detector and source apertures, enabling the maintenance of coherence in long-range laser beams despite the destructive action of air turbulence. The characteristics of air turbulence and its effect on laser beams are outlined. Maximum permissible source diameters vs distances for a He-Ne laser are tabulated, and the problem of coping with beam wandering is considered. B. B.

#### A65-28083

##### EXCITATION OF AUXILIARY OFF-AXIS LASER MODES.

M. P. Vaniukov, V. I. Isaenko, L. A. Luizova, and O. A. Shorokhov (Gosudarstvennyi Opticheskii Institut, Leningrad, USSR). (Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Jan. 1965, p. 3-6.)

Soviet Physics - JETP, vol. 21, July 1965, p. 1-3. 5 refs. Translation.

[For abstract see Accession no. A65-18454 08-16]

#### A65-28084

##### AMPLIFICATION OF LIGHT BY FOUR-LEVEL QUANTUM SYSTEMS.

Iu. A. Anan'ev, A. A. Mak, and B. M. Sedov (Gosudarstvennyi Opticheskii Institut, Leningrad, USSR). (Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Jan. 1965, p. 7-12.)

Soviet Physics - JETP, vol. 21, July 1965, p. 4-7. 5 refs. Translation.

[For abstract see Accession no. A65-18455 08-16]

#### A65-28089

##### EXCITATION OF MODES AND OSCILLATION KINETICS IN A RUBY LASER WITH A CONCENTRIC RESONATOR.

V. V. Korobkin, A. M. Leontovich, and M. N. Smirnova (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). (Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Jan. 1965, p. 78-86.)

Soviet Physics - JETP, vol. 21, July 1965, p. 53-58. 17 refs. Translation.

[For abstract see Accession no. A65-18460 08-16]

#### A65-28090

##### CHANGES IN THE RESONATOR OF A RUBY LASER WHEN HEATED BY PUMPING.

A. P. Veduta, A. M. Leontovich, and V. N. Smorchkov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). (Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Jan. 1965, p. 87-93.)

Soviet Physics - JETP, vol. 21, July 1965, p. 59-63. 13 refs. Translation.

[For abstract see Accession no. A65-18461 08-16]

#### A65-28091

##### CHARACTERISTICS OF A Q-SWITCHED RUBY LASER.

T. V. Gvaladze, I. K. Krasiuk, P. P. Pashinin, A. V. Prokhindeev, and A. M. Prokhorov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). (Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Jan. 1965, p. 106-110.)

Soviet Physics - JETP, vol. 21, July 1965, p. 72-74. 10 refs. Translation.

[For abstract see Accession no. A65-18462 08-16]

#### A65-28104

##### PHOTOGRAPHY BY LASER.

Emmett N. Leith and Juris Upatnieks.

Scientific American, vol. 212, June 1965, p. 24-35.

Description of a newly developed photographic technique, using coherent laser light, for producing interferometric patterns (holograms) on photographic films. By subsequently illuminating the holograms with laser-light beams, it is possible to obtain three-dimensional, virtual-image photographs of the original object. Moving the hologram, the laser, or the camera produces a parallax effect. To prepare the hologram, the laser beam used as illumination is passed through a partially reflecting and partially transmitting glass plate; the reflected part of the beam is made to illuminate the object (the reflected light from which falls on the photographic film), and the transmitted part of the beam (called the reference beam) impinges directly onto the film. An interferometric light pattern is thus formed with a grating-like structure that can be considered to be the two-dimensional analog of the wave pattern modulated so as to serve as a carrier of information about the light waves that produced it. Thus, a hologram is basically a phase-modulated reproduction of an interferometric fringe pattern. When the hologram is placed in a beam of coherent light, the light is demodulated, and two images are produced by the first-order diffracted waves emerging from the hologram interference grating. An apparent object (virtual image) appears at the original position where the object was located, and the conjugate or reversed curvature of the diffracted waves produces a real image which can be photographed directly without the need of a lens by placing a photographic plate at the position of the image. Applications include photographic methods for simulation and training devices and X-ray microscopy. D. P. F.

#### A65-28203

##### SPECTRUM OF LASER LIGHT SCATTERED FROM A SINGLE GIANT PULSE IN A LABORATORY PLASMA.

U. Ascoli Bartoli, J. Katzenstein, and L. Lovisetto (EURATOM and Comitato Nazionale per l'Energia Nucleare, Laboratorio Gas Ionizzati, Frascati, Italy).

Nature, vol. 207, July 3, 1965, p. 63, 64.

Observation of the spectrum of single-giant-pulse laser light scattered in a plasma. A fourteen-channel photoelectric spectrum analyzer with a Fabry-Perot etalon as the dispersing element was used for the observations. The signals of the different spectral channels were separated in time by making the time interval between them 5 nsec greater than the length of the giant pulse. A Kerr cell was placed in the system immediately before the etalon, so that light would be admitted to the analyzer only during the time of the giant pulse. The ion temperature computed from the profile obtained with this apparatus is found to be ~50 ev. The spectrum is said to show some evidence of the "shoulders" or weak maxima predicted by theory. The profile of the ion spectrum is found to correspond most nearly to that for equal electron and ion temperatures. A. B. K.

#### A65-28248 #

##### LASERS VERSUS MICROWAVES IN SPACE COMMUNICATIONS.

S. Gubin, R. B. Marsten, and D. Silverman (Radio Corporation of America, Defense Electronic Products, Astro-Electronics Div., Princeton, N.J.).

Institution of Navigation, and American Institute of Aeronautics and Astronautics, National Space Navigation and Spacecraft Communication Meeting, Houston, Tex., Apr. 29, 30, 1965, Paper. 15 p. 37 refs.

Comparative systems analysis of lasers and microwaves for Mars-to-Earth communications in the early 1970's. The mission objective is to transmit information from Mars to Earth, either by transmitting direct from the Mars-orbiting vehicle or by transmitting to an intermediate, Earth-orbiting satellite relay. It is assumed that devices for which performance is presently reported can be developed into flight equipment in the years remaining to the time frame of the mission. The choice of laser and microwave components is discussed, after which the attainable bit-per-second communication rates for the three links are analyzed. A performance criterion of bits per second per pound is also applied because of launch vehicle payload limitations. Systems problems which have

## A65-28249

led to particular choices of systems parameters are also discussed. It is concluded that, for the particular mission under consideration, microwave-system technology is better, and the microwave system is preferable.

R. A. F.

## A65-28249

### AIDS TO ACQUISITION IN OPTICAL COMMUNICATION.

E. B. Moss (Douglas Aircraft Co., Inc., Missile and Space Systems Div., Santa Monica, Calif.).

Institution of Navigation, and American Institute of Aeronautics and Astronautics, National Space Navigation and Spacecraft Communication Meeting, Houston, Tex., Apr. 29, 30, 1965, Paper. 20 p. 5 refs.

Discussion of acquisition and reacquisition in spacecraft communications using laser systems. Primary consideration is given to the general case of two spacecraft in space, with spacecraft-to-earth communication considered as a special case. Because of the interplanetary distances involved and the likelihood that extremely narrow bandwidths will be used, acquisition and reacquisition are thought to be problems of paramount importance. The theoretical considerations for the case of two spacecraft are described; the optical implications of these considerations are then discussed. The practicality of the scheme as a solution to the problem is considered, and various aids to tracking are discussed. It is concluded that synchronous scanning of a field of search with a narrow field telescope and with the illuminating beam of the laser can significantly shorten the time required for reacquisition.

R. A. F.

## A65-28335 #

### OBSERVATIONS OF RADIO SOURCES AT 9.4 GC/S WITH MASER AND HIGH-RESOLUTION INTERFEROMETER.

Haruo Tanaka, Takakiyo Kakinuma, Takashi Yamashita (Nagoya University, Research Institute of Atmospheric Physics, Nagoya, Japan), Hidenari Uchida, Humio Inaba (Tohoku University, Research Institute of Electrical Communication, Sendai, Japan), Hiroshi Tsuru, Kenichi Takahashi, Syogo Yoshikawa, Hidekichi Hozumi, and Hiromi Hayashi (Nippon Electric Co., Ltd., Communication Research Laboratory, Tokyo, Japan).

Nagoya University, Research Institute of Atmospheric Physics, Proceedings, vol. 12, Jan. 1965, p. 35-48. 29 refs.

Observations of Cygnus A, Taurus A, Orion Nebula, and Omega Nebula at 9.4 Gc, made with the 2.2' fan beam of a 16-element interferometer and a maser amplifier. Cygnus A was also observed with the 0.7' fan beam of a compound interferometer. The maser amplifier for radio astronomical observations was developed with special emphasis on high-stability performance and convenience of adjustment and handling in field installations. The voltage-gain bandwidth product is about 100 Mc, the noise temperature is 400°K, and the gain instability is 0.1 db up to 30 min and 0.2 db up to 2 hr. The brightness distributions, sizes, and flux densities of the radio sources are compared with the results of earlier observations. Flux densities of the sources have been derived from that of the sun, comparing the areas under the drift curves of the sources with that of the sun. The results of flux density measurements are considered to show that the scale of flux density at 9.4 Gc of the solar observations is nearly equal to the average scale of the galactic or extragalactic observations.

(Author) F. R. L.

## A65-28419

### FOCUSING ULTRASONIC SYSTEM APPLICABLE TO TWO-DIMENSIONAL OPTICAL BEAM SCANNING AND LASER OUTPUT MODULATION.

David E. Flinchbaugh (United Aircraft Corp., Research Laboratories, East Hartford, Conn.).

Acoustical Society of America, Journal, vol. 37, June 1965, p. 975-985. 21 refs.

Army-supported research.

Experimental investigation utilizing a barium titanate ceramic transducer formed into an arc of a short section of right circular cylinder and radiating into a cell filled with a tetrachloroethylene at 400 kc/sec. A helium-neon laser beam was used to examine the index of refraction gradients produced in the liquid and to illustrate the possible deflection patterns. When the beam traversed the cell near the focal line, circular scanning was observed, with maximum deflection angles of approximately  $\pm 1.0^\circ$ . Linear scanning reached

$\pm 1.3^\circ$ . Data describing the experimentally observed beam motion showed good agreement with a theoretical analysis of the complex acoustic field in this region. Deflections produced by pulse excitation of the transducer exceeded  $\pm 1.5^\circ$ . Ruby laser spiking was modulated to follow the 400-kc/sec field, and, in pulsed operation, giant spikes were obtained, using the cell to control the Q of the optical resonator cavity. High-speed photographs of both the partial standing acoustic wave, the traveling shock waves, and the circular beam-deflection pattern were taken.

(Author) M. M.

## A65-28487 #

### CONTRIBUTION TO THE ELECTROMAGNETIC THEORY OF THE INJECTION LASER [K ELEKTROMAGNITNOI TEORII INZHEKTSIONNOGO LAZERA].

R. F. Kazarinov, O. V. Konstantinov, V. I. Perel', and A. L. Efros (Akademiia Nauk SSSR, Fiziko-Tekhnicheskii Institut, Leningrad, USSR).

Fizika Tverdogo Tela, vol. 7, May 1965, p. 1506-1516. 14 refs. In Russian.

Calculation of the quantum-yield coefficient of stimulated emission and the angular distribution of the emission from a laser diode. The quantum-yield coefficient is obtained as the ratio of the emitted power to the power generated by radiative recombination in the active region. It is found that the angular distribution of the emission in a plane normal to the junction can have two peaks, the widths of which are defined by the penetration depth of the field into p and n materials. The angular distance between the peaks characterizes the gain in the active region.

V. P.

## A65-28492 #

### CREATION OF SUPERCONDUCTING STATES IN IMPURITY-FREE SEMICONDUCTORS BY ILLUMINATION WITH A POWERFUL LASER [O SOZDANII SVERKHPROVODIASCHIKH SOSTOIANII V BESPRIMESNYKH POLUPROVODNIKAKH PUTEM OSVESHCHENIIA IKH MOSHCHNYM LAZEROM].

A. S. Selivanenko (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Fizika Tverdogo Tela, vol. 7, May 1965, p. 1567, 1568. 6 refs. In Russian.

Analysis showing that, in principle, it is possible to create superconducting states at sufficiently low temperatures in pure (unalloyed) semiconductors having a suitably shaped conduction band. Particular attention is given to semiconductors (and here to SrTiO<sub>3</sub>) in which superconductivity has already been achieved when using alloyed specimens. It is shown that instead of using impurities to create the required electron density in the conduction band, it is possible to achieve the same effect by exposing the semiconductor to laser light.

V. P.

## A65-28538 #

### DIFFRACTION SYNCHRONIZATION OF OPTICAL MASERS [DIFRAKSIONNAIA SINKHRONIZATSIYA OPTICHESKIKH KVANTOVYKH GENERATOROV].

N. G. Basov, E. M. Belenov, and V. S. Letokhov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Zhurnal Tekhnicheskoi Fiziki, vol. 35, June 1965, p. 1098-1105. 12 refs. In Russian.

Analytical investigation of the conditions for the existence of a synchronized mode of excitation of the principal oscillation types in a diffraction-coupled laser. The synchronization of two lasers is examined. The diffraction-coupling coefficient of two open resonators is calculated, and the values of the laser parameters which provide a stable synchronization mode are determined.

V. P.

## A65-28554

### ANGULAR MODES IN A GAS LASER.

I. M. Belousova, O. B. Danilov, and B. A. Ermakov (Gosudarstvennyi Opticheskii Institut, Leningrad, USSR).

(Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 47, Dec. 1964, p. 2013-2018.)

Soviet Physics - JETP, vol. 20, June 1965, p. 1351-1354. 6 refs. Translation.

[For abstract see Accession no. A65-15458 06-16]

**A65-28556****TRANSIENTS IN THREE-LEVEL MASERS.**

A. A. Manenkov, R. M. Martirosian, Iu. P. Pimenov, A. M. Prokhorov, and V. A. Sychugov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 47, Dec. 1964, p. 2055-2063.)

Soviet Physics - JETP, vol. 20, June 1965, p. 1381-1386. 16 refs. Translation.

[For abstract see Accession no. A65-15460 06-09]

**A65-28590 \*****MIRROR MOUNTS FOR EXPERIMENTAL OPTICAL MASERS.**

L. J. Collins and J. Smith (Mullard, Ltd., Mullard Research Laboratories, Salfords, Surrey, England).

Journal of Scientific Instruments, vol. 42, July 1965, p. 499, 500.

Description of a mirror holder with deformable hinges giving two constant hinge lines at right angles which can be mounted on an optical bench and is useful in experiments with gaseous optical maser tubes and solid-state optical masers. The main features of the design consist of (1) a support fitting a standard optical-bench saddle which provides coarse adjustment about a vertical axis, (2) a clamp for horizontal axis adjustment, (3) a main ring carrying an intermediate ring on two hinges arranged to form a horizontal line, (4) two micrometers for fine adjustments, and (5) a mirror held by small leaf springs against the front edge of a support bolted to the front of the mirror ring. As the hinge lines do not pass through the center of the mirror surface, the cavity distance between two such mirrors is not held constant when the mirror angle is changed.

D. P. F.

**A65-28626****STUDY OF THE PARAMETRIC CONVERSION OF OPTICAL FREQUENCIES [ETUDE DE CONVERSION PARAMETRIQUE DE FREQUENCES OPTIQUES].**

Nguyen-Van-Tran and Denis Kehl (Compagnie Générale d'Electricité, Centre de Recherches, Département de Recherches Physiques de Base, Marcoussis, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 260, no. 26, June 28, 1965, p. 6838-6841. 7 refs. In French.

Experimental investigation of the parametric conversion of optical frequencies in a crystal where the sources of illumination are coherent oscillators which are mutually pulsed and synchronized. The two ruby and doped-glass lasers are triggered by the same rotating prism; to obtain synchronization of the two pulses one of the two auxiliary prisms  $P_1$  and  $P_2$  is suitably rotated about its axis. The signal wavelength emitted by the doped-glass laser (10,600 Å) is mixed with the pump wavelength in the second of two  $\text{PO}_4\text{H}_2\text{K}$  crystals so as to produce a wavelength the frequency of which is equal to the difference between that of the pump and signal frequency. This "idler" frequency is equal to 5150 Å. Experiments indicate that there is parametric amplification of the idler frequency.

D. P. F.

**A65-29075****TIME DEVELOPMENT OF A LASER SIGNAL.**

Bertram Pariser and Thomas C. Marshall (Columbia University, Plasma Laboratory, New York, N.Y.).

Applied Physics Letters, vol. 6, June 15, 1965, p. 232-234. Contract No. Nonr-266(93).

Discussion of an experimental study of the growth of energy in a laser cavity. The output intensity of an He-Ne laser was reduced in a manner which neither altered the properties of the optical cavity nor the gaseous discharge. Oscillations at the visible and infrared transitions were quenched by pumping particles into the lower neon laser state. The recovery of the laser signal was then observed for many radiative decay time constants after the pumping process was completed. Graphs of laser output as a function of time after quenching are presented.

S. H. B.

**A65-29117****FREQUENCY STABILIZATION OF THE He-Ne MASER.**

Koichi Shimoda (Tokyo, University, Dept. of Physics, Tokyo, Japan).

(Institute of Electrical and Electronics Engineers, Conference on Precision Electromagnetic Measurements, National Bureau of Standards Laboratories, Boulder, Colo., June 23-25, 1964, Paper.) IEEE Transactions on Instrumentation and Measurement, vol. IM-13, Dec. 1964, p. 170-174. 8 refs.

NASA-supported research.

Observation of the photobeat between two independently stabilized He-Ne masers. In the experiment described the separation of the mirrors is modulated at a low frequency with a small amplitude. Correction signals for the tilt angle of the mirrors, the power level of the excitation, and the separation of the mirrors are given, respectively, by the fundamental, the second harmonic, and the third harmonic of the modulation frequency. The observed fluctuation of beat frequencies is said to show a Gaussian distribution and no systematic frequency drift. It is found that the frequency of each maser stays within several parts in  $10^{10}$  and the resettability is just as good. Some difficulties with the stray magnetic field from magnetostriction coils and with the earth's magnetic field are found. Preliminary experiments on pressure shift and its effect on the stabilized maser are discussed. The theory is developed, and the frequency deviations are calculated as functions of the gas pressure and of the modulation amplitude.

(Author) A. B. K.

**A65-29119****EXCHANGE COLLISIONS, WALL INTERACTIONS, AND RESETTABILITY OF THE HYDROGEN MASER.**

J. Vanier, H. E. Peters, and R. F. C. Vessot (Varian Associates, Beverly, Mass.).

(Institute of Electrical and Electronics Engineers, Conference on Precision Electromagnetic Measurements, National Bureau of Standards Laboratories, Boulder, Colo., June 23-25, 1964, Paper.) IEEE Transactions on Instrumentation and Measurement, vol. IM-13, Dec. 1964, p. 185-188. 10 refs.

Description of experiments to verify the resettability of the hydrogen maser. In the experimental method used the output frequency of one maser was measured against the hydrogen pressure. It was found that at a given tuning of the cavity no shift larger than 2.1 parts in  $10^{13}$  is observed for a change of 4 to 1 in pressure. It is also shown that the pressure shift due to exchange collisions, predicted by Bender, cannot be observed for the field-independent transition in the hydrogen maser. Two masers having the same storage-bulb design and the same wall coating were tuned by this technique and were found to have a frequency difference of 7.6 parts in  $10^{13}$ . Experiments on the wall coating of the hydrogen-maser storage bulb were made. Relaxation and decorrelation times of various materials were measured. The hyperfine splitting of the ground state of hydrogen measured against cesium is also given.

(Author) A. B. K.

**A65-29164****TRANSMISSION OF HIGH-POWER LASER LIGHT THROUGH TAPERED DIELECTRIC TUBES AND RODS.**

K. Vogel (Uppsala, University, Institute of Physics, Uppsala, Sweden).

Nature, vol. 207, July 17, 1965, p. 281, 282.

Investigation of the transmission of high-power laser light by means of dielectric tubes and rods using a Q-switched ruby laser and a calibrated "rat's nest" bolometer. No shift in the shape of the transmitted laser pulse was recorded. Radiation damage in the guide material could not be observed. The power density that can be achieved by tapered guides seems to be sufficiently high to be useful in, for example, biological applications when it is desired to irradiate small areas with a rather well defined energy distribution and when it is of interest to replace conventional focusing systems by a more flexible light guide system. Experimental values are tabulated for energy transmission ratio, directivity, and density coefficient.

M. F.

**A65-29196****WIDE BANDWIDTH TRAVELING WAVE MASER EMPLOYING MAGNETIC STAGGER TUNING.**



## A65-29198

J. P. McEvoy, Jr., D. J. Miller, and L. C. Morris (Radio Corporation of America, Camden, N.J.).  
Solid-State Electronics, vol. 8, Apr. 1965, p. 443-448. 8 refs.  
 Contract No. NAS 5-3773.

Study of experimental work which shows that magnetic stagger tuning provides an efficient means for trading excess gain for bandwidth in traveling-wave masers. A high-gain traveling-wave maser (20 db/in. at 4.2°K) has been developed at 4000 Mc and operated with a transverse field superconducting magnet as a wide-band amplifier system. The maser, which employs meander-line slowing and iron-doped rutile as the active material, is operated with various sections of the paramagnetic crystal resonating at different frequencies. This is made possible by placing the maser in a superconducting magnet which generates a field profile that can be varied in steps along its length of the maser. A 4.0-in. iron-doped rutile crystal, which produces 78-db peak electronic gain over a 12-Mc instantaneous band, can be made to yield 33 db of gain and 66 Mc of bandwidth by stagger tuning. In addition to presenting experimental data which are in good agreement with the simple theory of magnetic stagger tuning, this paper describes for the first time the performance of a traveling-wave maser which is magnetically stagger-tuned in a small compact superconducting magnet. This work is significant from a system standpoint, since an electronically, variable-gain/bandwidth microwave amplifier has been developed. Furthermore, both these devices can be operated in a closed-cycle helium refrigerator.

(Author) M. F.

## A65-29198

### LASER ACTION IN AN ALLOYED GaAs JUNCTION.

G. Cayman (Philips' Gloeilampenfabrieken, Philips Research Laboratories, Eindhoven, Netherlands).

Solid-State Electronics, vol. 8, Apr. 1965, p. 455, 456.

Announcement of the manufacture of an alloyed junction GaAs diode which, when submerged in liquid nitrogen, showed laser action at a wavelength of 8390 Å, corresponding to a photon energy of 1.48 eV. The threshold current at which the spectral narrowing and mode selection of the emitted radiation took place was  $4 \times 10^4$  amp/cm<sup>2</sup>. Although the experiments have shown that it is possible to make alloyed lasers, they also showed that the alloying process is very critical and tends to be very irreproducible.

M. F.

## A65-29242 #

### LASER ELECTRO-OPTICAL NAVIGATION SYSTEM.

Robert M. Williams (General Dynamics Corp., General Dynamics/Convair, San Diego, Calif.).

IN: NATIONAL AEROSPACE ELECTRONICS CONFERENCE, 17TH, DAYTON, OHIO, MAY 10-12, 1965, PROCEEDINGS. [A65-29228 18-09]

Conference sponsored by the Professional Group on Aerospace and Navigational Electronics, Dayton Section of the Institute of Electrical and Electronics Engineers, and American Institute of Aeronautics and Astronautics.

Dayton, Institute of Electrical and Electronics Engineers, Dayton Section, 1965, p. 120-125. 11 refs.

Detailed feasibility analysis of a satellite-borne electro-optical angular tracker and a well surveyed earth-based corner-reflector sensor system. The sensor system includes a laser system for illuminating the corner reflector, an amplitude-comparison photomultiplier system for corner-reflector acquisition and tracking, and an interferometer fine-track sensor. Tracking accuracies of 5 μrad are postulated for the amplitude-comparison tracker, ignoring atmospheric effects, and 0.5 μrad for the 1-ft-baseline interferometer tracker.

A. B. K.

## A65-29265 #

### INTERACTION OF COHERENT LIGHT BEAMS WITH MICROWAVE SOUND.

C. F. Quate, C. D. W. Wilkinson, and D. Caddes (Stanford University, Laboratories of Physics, Stanford, Calif.).

IN: NATIONAL AEROSPACE ELECTRONICS CONFERENCE, 17TH, DAYTON, OHIO, MAY 10-12, 1965, PROCEEDINGS. [A65-29228 18-09]

Conference sponsored by the Professional Group on Aerospace and Navigational Electronics, Dayton Section of the Institute of Electrical and Electronics Engineers, and American Institute of Aeronautics and Astronautics.

Dayton, Institute of Electrical and Electronics Engineers, Dayton Section, 1965, p. 300-302. 10 refs.

Brief report on the diffraction of light by hypersound in transparent crystals. The results of experiments with 6328-Å laser light and sound waves of frequencies above 400 Mc are presented. In addition to providing a means of shifting a coherent light beam in frequency and translating the beam in space, acoustic diffraction also provides a method of extracting a small amount of power from the primary light beam.

S. H. B.

## A65-29267 #

### THE SUPER-MODE LASER.

Gail A. Massey, M. Kenneth Oshman, and Russell Targ (Sylvania Electronic Products, Inc., Sylvania Electronic Systems Div., Mountain View, Calif.).

IN: NATIONAL AEROSPACE ELECTRONICS CONFERENCE, 17TH, DAYTON, OHIO, MAY 10-12, 1965, PROCEEDINGS. [A65-29228 18-09]

Conference sponsored by the Professional Group on Aerospace and Navigational Electronics, Dayton Section of the Institute of Electrical and Electronics Engineers, and American Institute of Aeronautics and Astronautics.

Dayton, Institute of Electrical and Electronics Engineers, Dayton Section, 1965, p. 310-315. 9 refs.

Contract No. AF 33(615)-1938.

Discussion of improvements in the monochromaticity of laser outputs. Standard techniques for coping with the problem of multimode oscillations in lasers, such as shortening the cavity or increasing the number of mirrors in the cavity, reduce the total output power. Mode locking techniques and the use of FM lasers are evaluated. The supermode laser, a single-frequency generation system, consists of an FM laser with a synchronous phase modulator at the output. The supermode laser achieves short-term coherence at a single frequency and, it is indicated, may have applications in heterodyne communications, interferometry, and holography.

S. H. B.

## A65-29275 #

### FIELD TESTING OF A SELF-CONTAINED LASER NAVIGATION SYSTEM.

R. A. Flower (General Precision, Inc., General Precision Aerospace Group, GPL Div., Pleasantville, N. Y.).

IN: NATIONAL AEROSPACE ELECTRONICS CONFERENCE, 17TH, DAYTON, OHIO, MAY 10-12, 1965, PROCEEDINGS. [A65-29228 18-09]

Conference sponsored by the Professional Group on Aerospace and Navigational Electronics, Dayton Section of the Institute of Electrical and Electronics Engineers, and American Institute of Aeronautics and Astronautics.

Dayton, Institute of Electrical and Electronics Engineers, Dayton Section, 1965, p. 392-398.

Description of the testing of the Optical Diffraction Velocimeter. In the operation of this device, a suitably shaped beam from a CW laser carried by a vehicle illuminates a small patch of terrain beneath the vehicle. By virtue of the spatial and temporal coherence of the laser light, the energy reradiated by the terrain forms a diffraction pattern which moves in space in opposition to the motion of the vehicle along the terrain. Velocity measurement is accomplished by sensing the magnitude and direction of the pattern motion. After laboratory testing, the system was field-tested in a small truck. The results of such tests over improved roads and distances ranging from less than 1 to 30 miles indicate the feasibility of such an instrument for accurate navigation.

S. H. B.

## A65-29356

### THE BEHAVIOR OF GaAs LASER DIODES AT HIGH RADIATION LOADS [DAS VERHALTEN VON GaAs-LASERDIODEN BEI HOHEN STRAHLUNGSLEISTUNGEN].

H. J. Henkel, E. Klein, and H. Kuckuck (Siemens-Schuckertwerke AG, Forschungslaboratorium, Erlangen, West Germany).

Solid-State Electronics, vol. 8, May 1965, p. 475-478. In German. Research supported by the Bundesministerium für wissenschaftliche Forschung.

Investigation of the behavior of GaAs laser diodes at high pulse loads. For pulse currents of 500 amp a radiated power of 80 w could be achieved. It was found that the maximum power obtainable is limited by the temperature rise in the diode. A further increase may be expected if shorter pulses are used. The directional distribution and the spectrum of the radiation were measured. (Author) F.R.L.

#### A65-29411

##### FREQUENCY STABILIZATION OF DOUBLE-MODE GAS LASER.

H. D. Goldick (Syracuse University, Research Corp., Electronics Research Laboratory, Syracuse, N.Y.).

IEEE, Proceedings, vol. 53, June 1965, p. 638.

Contract No. NAS 5-3927.

Discussion of a circuit employed to phase-lock the self-beat of a gas laser to a frequency standard. The laser used was an rf-pumped helium-neon laser operating at 6328 Å in a hemispherical configuration. The circuit used in this experiment is shown. The laser was adjusted so that the only modes excited were two of the longitudinal type. This was accomplished by using low rf power and adjusting the mirrors while checking the display of the laser self-beat (approximately 250 Mc) on a Polarad spectrum analyzer and seeing that the only laser-derived signal was at that frequency. These modes were received and mixed in an RCA 7102 photomultiplier tube, and the beat frequency signal was then amplified and beat down to 30 Mc. This signal was then referenced against a 30-Mc signal derived from a frequency standard in a phase detector, and the resulting error signal was amplified and used to change the length of the laser cavity by means of the rear (flat) mirror mounted on a stack of PZT (lead zirconate titanate) disks. The analysis circuit used to measure the stability of the laser self-beat is shown. The measurements were made in a typical laboratory environment. Various equipments, such as oscilloscopes, signal generators, and air conditioning were running. M.M.

#### A65-29418

##### OPTICAL SIMULATION OF MICROWAVE ANTENNAS WITHOUT DIRECT FREQUENCY SCALING.

Henry W. Redlien, Jr. and Herman M. Heinemann (Wheeler Laboratories, Laser Engineering Group, Smithtown, N.Y.).

IEEE, Proceedings, vol. 53, June 1965, p. 648, 649.

Description of optical simulation, an alternative to direct frequency scaling, which is applicable to antenna apertures of an extent of at least several wavelengths. In this approach, the required amplitude distribution of the radiation fields, or "shape" of the radiation pattern, is obtained even though the angular scale is distorted. By shape is meant the relative amplitude response of the various parts of the pattern. The correct pattern shape is obtained with optical simulation if the distribution of the fields in the aperture is identical in amplitude and phase with those of the microwave antenna. The optical aperture, when measured in wavelengths, is larger than the corresponding microwave aperture, and the angular extent of the pattern is reduced; the ratio of the wavelength size of the actual and simulated apertures then becomes a scale factor for the angle of radiation. If the pattern angle is suitably normalized, the simulated patterns can be applied to any size aperture at any wavelength. Therefore, optical simulation becomes practical since larger test apertures, of the order of several centimeters, may be constructed and adjusted to provide the distributions closely approximating those of microwave antennas. The field distributions may be provided by either the natural shape of the appropriate radiation mode of the laser output, when applicable, or by the insertion of attenuating films which vary in the prescribed manner across the aperture. Phase control may be obtained in part by the choice of laser modes and in part by films of varying thickness. M.M.

#### A65-29430

##### SPECTROMETER FOR LASER ANALYSIS.

Semiconductor Products and Solid State Technology, vol. 8, July 1965, p. 14-16.

Description of a newly developed spectrometer for analysis and adjustment of laser frequencies of oscillation. The instrument automatically varies the separation between two interferometer mirrors to scan the spectrum of a light source by using a piezoelectric ceramic tube as a spacer in a Fabry-Pérot interferometer. Voltages to provide linear changes in the tube are supplied by dry

cells, and the required tube oscillation is obtained from a variable transformer across a 60-cps power line. On leaving the interferometer the light intensity structure within the fringes passes through a diaphragm and then to a photomultiplier tube. The latter is coupled by cathode follower (for impedance matching) to an oscilloscope. The device provides a rapid means for investigating laser frequencies and modes, since the photomultiplier tube can scan a laser spectrum for the oscilloscope in 1/60 sec. D.P.F.

#### A65-29447

##### A 2388 MC TWO-CAVITY MASER FOR PLANETARY RADAR.

Robert C. Clauss (California Institute of Technology, Jet Propulsion Laboratory, Communications Elements Research Section, Pasadena, Calif.).

Microwave Journal, vol. 8, May 1965, p. 74-77. 6 refs.

Description of a two-cavity maser fabricated by simple and rugged construction techniques which has proved to be a useful device for radar and radio astronomy. High gain and good gain stability are achieved in a liquid-helium bath at 4.2°K. Operation at a fixed frequency with a small bandwidth requirement enables the cavity maser to compare favorably with more sophisticated amplifiers. The maser was used to receive radar echoes and measure blackbody radiation from Venus during the period from Oct. through Dec. 1962. After modifications in Jan. 1963 the 35°K receiving system was used to receive radar echoes from Venus, Mars, and Mercury. The system has also been used in radiometric experiments to determine antenna parameters and radio source intensity and ellipticity. The continuous daily use of the device over a period of five months indicates the success of the cryogenic system, on which reliable field operation of a maser system depends. F.R.L.

#### A65-29505

##### LASER EFFICIENCY AT HIGH PUMP LEVELS.

A. C. Scott (Wisconsin, University, Dept. of Electrical Engineering, Madison, Wis.).

Solid-State Electronics, vol. 8, June 1965, p. 551-561. 9 refs.

NSF-supported research.

Analysis of a simple model for a laser oscillator to determine the single-mode efficiency for steady-state operation at high pumping levels. The analysis takes into account the possibility of changes in the shape of the electromagnetic mode as the pumping rate is increased. Normalized plots of laser efficiency as a function of pumping rate and laser length indicate that changes in mode shape are important at moderate pump levels. (Author) M.M.

#### A65-29525

##### LOW-LOSS MULTILAYER DIELECTRIC MIRRORS.

D. L. Perry (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

(Institute of Electrical and Electronics Engineers, Northeast Electronics Research and Engineering Meeting, Boston, Mass., Nov. 3-5, 1965, Paper.)

Applied Optics, vol. 4, Aug. 1965, p. 987-991. 6 refs.

Description of the preparation of low-loss multilayer dielectric coatings for laser mirrors. Layer thickness is controlled by a unique monitoring system using a 6328-Å gas laser as a light source. Experiments designed to evaluate and reduce losses in the mirror coatings are discussed. It is found that mirror transmission losses can be reduced to a negligible value by deposition of a sufficient number of dielectric layers, without at the same time increasing scattering and absorption losses. Reflectivities in excess of 99.8% have been obtained from a single stack of 25 quarter-wave layers. Broad-band mirrors with reflectivities greater than 99.5% from 4300 Å to 7400 Å have been produced by properly stacking two such 25-layer groups. (Author) D.P.F.

#### A65-29528

##### OPTICAL COATINGS FOR LASER USE.

Milton Laikin (Purkyně University, Institute of Physics, Brno, Czechoslovakia).

Applied Optics, vol. 4, Aug. 1965, p. 1032, 1033. 15 refs.

Discussion of thin films in relation to the optical requirements of lasers. The properties of a laser, which include high peak power, emission of monochromatic light, and gain which is very sensitive

## A65-29529

to reflectivity, impose severe requirements on thin-film performance. The most common material for antireflection work is  $\text{MgF}_2$ ; it is transparent in the 0.11- to 7.5- $\mu$  range and is readily evaporated by conventional techniques. Silicon monoxide is ideally suited to gallium arsenide injection lasers. High reflectivity is obtained by alternating layers of high index with low-index materials, such as  $\text{CeO}_2$  with  $\text{MgF}_2$ . A 15-layer mirror was made for 1.06- $\mu$  laser use; transmission measured 0.05% and reflectivity 99.34%. Other coating materials, such as gadolinium titanate and lanthanum oxide, are described.

D.P.F.

## A65-29529

### OPTICAL DISTORTION IN RUBY LASERS DURING PUMPING.

D. White and D. Gregg (California, University, Lawrence Radiation Laboratory, Livermore, Calif.).

*Applied Optics*, vol. 4, Aug. 1965, p. 1034.

AEC-sponsored research.

Description of a technique for direct measurement of the increased beam divergence of 6943-Å light caused by a single pass through a ruby laser amplifier during pumping. It is shown that the divergence at the time of maximum gain in the rod, 750  $\mu$ sec, was twice the initial beam divergence. The technique consisted of passing a collimated 200- $\mu$ sec spontaneous lasing pulse from a ruby laser through a ruby amplifier and photographing the emergent beam on a screen 60 m distant. The time of arrival taken was for the first two-thirds of the 200- $\mu$ sec pulse. In this way a sequence of pictures was obtained showing the beam divergence as a function of time after the initiation of the flashlamps.

D.P.F.

## A65-29530

### POLARIZATION EFFECTS IN A ROOF-TOP RUBY LASER.

W. E. K. Gibbs and R. E. Whitcher (Department of Supply, Australian Defence Scientific Service, Defence Standards Laboratories, Maribyrnong, Victoria, Australia).

*Applied Optics*, vol. 4, Aug. 1965, p. 1034, 1035.

Description of polarization effects observed in a ruby laser consisting of a right-angle roof-topped rod with c axis perpendicular to the roof edge, external multilayer dielectric reflector, and helical flashtube. Analysis by Polaroid sheet showed that portions A and B were polarized perpendicular and parallel to the ruby c axis, respectively. The intensity of B was about 10% that of A. The angular separation of the two portions B ( $\sim 10^\circ$ ) indicates that they are not due to off-axis modes, and it would appear that they are derived from the central portion A by a reflection or scattering process that involves a change of polarization. A theoretical explanation of these effects is developed. The above effects are of advantage in Pockels-cell Q switching, where the parallel polarized light will be reflected out of the cavity without the use of a Rochon prism.

D.P.F.

## A65-29531

### OBSERVATION OF THE TRANSVERSE MODES OF A LASER WITH A SCANNING INTERFEROMETER.

P. W. Smith (Bell Telephone Laboratories, Inc., Crawford Hill Laboratory, Holmdel, N.J.).

*Applied Optics*, vol. 4, Aug. 1965, p. 1038-1040. 5 refs.

Demonstration that a scanning interferometer can be designed to analyze the output of a laser oscillating simultaneously in many transverse modes. A lens or lenses must be inserted in the light beam between the laser and the interferometer in order to match the beam to the interferometer and avoid the excitation of unwanted modes of the interferometer. When the beam is properly matched, the laser output in the fundamental transverse mode excites only the fundamental mode of the interferometer, the output in the second-order mode excites the second-order mode of the interferometer, etc. A formula is developed for determining the power transmitted through the interferometer as its length is varied. From this an equation is developed which gives the information needed to design a scanning interferometer for the observation of transverse modes.

D.P.F.

## A65-29538

### MEASUREMENTS OF THE CHARACTERISTICS OF A CLOUD OF METALLIC PLASMA [MESURES DES CARACTERISTIQUES D'UNE BOUFFEE DE PLASMA METALLIQUE].

Térenzio Consoli, Claude Gormezano, and Lucien Slama (Commissariat à l'Energie Atomique, Centre d'Etudes Nucléaires de Saclay, Service de Physique Appliquée, Gif-sur-Yvette, Seine-et-Oise, France).

*Académie des Sciences (Paris), Comptes Rendus*, vol. 261, no. 1, July 5, 1965, p. 86-89. In French.

Description of the experimental determination of the density, temperature, and speed of expansion of a plasma cloud produced in a time interval of less than  $10^{-7}$  sec (which is easily reproducible) by the impact of a ruby laser beam on an aluminum strip. The plasma cloud is produced by the impact of a monopulsed laser beam ( $P \approx 1$  Mw during 30 nsec), focused by a lens having a 10-cm focal length on a strip of aluminum. The plasma cloud as it expands crosses a continuous gas laser beam which is normal to the first laser beam and directed tangentially at the aluminum strip and 1 mm to the side of it. This latter beam acts as a two-way optical interferometer. On removal of the interferometer mirror  $M_1$  and in the same tangential position, provision is made for placing seven electrical probes, or alternatively analyzing the light with a spectrograph or image converter.

D. P. F.

## A65-29539

### INTERPRETATION OF THE PHENOMENA CONNECTED WITH THE EMISSION OF THE SECOND HARMONIC IN A NONLINEAR CRYSTAL EXCITED BY RAY $R_1$ OF A RUBY LASER [INTERPRETATION DES PHENOMENES LIES A L'EMISSION DU SECOND HARMONIQUE DANS UN CRISTAL NON LINEAIRE EXCITE PAR LA RAYE $R_1$ D'UN LASER A RUBIS].

Jean-Charles Vienot and Claude Froehly (Besançon, Université, Laboratoire de Physique Générale et Optique, Besançon, France).

*Académie des Sciences (Paris), Comptes Rendus*, vol. 261, no. 1, July 5, 1965, p. 91-93. In French.

Investigation of the second harmonic observable when a beam from a ruby laser traverses a KDP crystal, which is accompanied by infinite diffraction phenomena. The latter can be explained in terms of a simple hypothesis concerning the amplitude distribution in the regions of emission. This hypothesis leads to numerical results which are in good agreement with the photographic recordings of the phenomena.

D. P. F.

## A65-29569 #

### ON IONIZING SHOCK WAVE PLASMA DIAGNOSTICS.

B. Miller, T. Marshall, and R. A. Gross (Columbia University, New York, N.Y.).

USAF, Office of Scientific Research and United Aircraft Corp., Symposium on Advanced Propulsion Concepts, 4th, Palo Alto, Calif., Apr. 26-28, 1965, Paper. 24 p. 13 refs. Contract No. AF 49(638)-1254.

Investigation of probe measurements of the magnetic field of a plasma which is in motion with respect to the probe. The measurements of plasma properties and their associated electromagnetic fields is defined as a complex and difficult experimental problem. The usual integration with respect to time is, in general, not proper; the correct expressions for the case of a plasma and its associated fields produced by a strong shock wave in an electromagnetically driven shock tube are developed. The fundamental relationships for the relatively new technique of measuring electron density by the use of coherent light are described. Both these techniques are particularly relevant to measurements of dense, hot, transient plasmas, such as those generated by strong ionizing shock waves.

(Author) D.P.F.

## A65-29669 #

### UNCONVENTIONAL INERTIAL SENSORS.

Robert C. Langford (General Precision, Inc., Aerospace Research Center, Little Falls, N.J.; NASA, Electronics Research Center, Cambridge, Mass.).

American Institute of Aeronautics and Astronautics, Annual Meeting, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-401. 33 p. 40 refs.

Members, \$0.50; nonmembers, \$1.00.

Survey of nine lines of research in unconventional sensors that are under vigorous study, are of most concern, or appear to offer particular promise. With reference to devices, sections are devoted to ring laser sensors, electrostatic gyroscopes, fluid

sphere gyroscopes, magnetic resonance gyroscopes, and super-conductivity gyroscopes. Methods of operation, the present state of development, and performances are discussed. Current research endeavors which may make additional devices possible are described. Such research covers relativistic sensing, rotating tensor sensing, vortex-rate sensing, and quantum-mechanical effects.

F.R.L.

#### A65-29791

##### HIGH-FREQUENCY LASER INTERFEROMETRY IN PLASMA DIAGNOSTICS.

J. B. Gerardo, J. T. Verdeyen, and M. A. Gusinow (Illinois, University, Dept. of Electrical Engineering, Urbana, Ill.). *Journal of Applied Physics*, vol. 36, July 1965, p. 2146-2151. 13 refs.

Army-supported research.

Study of the time response of a laser interferometer and the parameters that are instrumental in limiting its time response. It is shown that by judicious selection of parameters the laser interferometer is capable of detecting resonances in excess of  $50 (\mu\text{sec})^{-1}$ , which is close to the theoretical limit of the resonant structure used. The applicability of the interferometer to measurement of very rapidly changing plasma electron densities is demonstrated.

(Author) R.A.F.

#### A65-29792

##### ENERGY DISTRIBUTION IN A GLASS $\text{Nd}^{3+}$ LASER ROD.

N. F. Borrelli and M. L. Charters (Corning Glass Works, Research and Development Laboratory, Corning, N.Y.). *Journal of Applied Physics*, vol. 36, July 1965, p. 2172-2174.

Determination of the radial dependence of the absorbed-energy distribution in a cylindrical rod of  $\text{Nd}^{3+}$ -glass pumped with a xenon source. Using the exact  $\text{Nd}^{3+}$ -glass absorption spectrum, both the total absorbed energy and the absorbed inversion energy are calculated to determine the magnitude of the energy dissipated by the host glass. In general, absorbed inversion energy and the dissipated energy are not uniform across the radius of the rod, although a value of  $5 \times 10^{20}$  ions/cm<sup>2</sup> for the  $\text{Nd}^{3+}$  concentration, multiplied by the rod radius, gives a fairly uniform distribution.

(Author) R.A.F.

#### A65-29799

##### TRANSITION PROBABILITIES FOR SOME Ar II LASER LINES.

H. Statz, F. A. Horrigan, S. H. Koozekanani (Raytheon Co., Research Div., Waltham, Mass.), C. L. Tang (Cornell University, School of Electrical Engineering, Ithaca, N.Y.), and G. F. Koster (Massachusetts Institute of Technology, Dept. of Physics, Cambridge, Mass.). *Journal of Applied Physics*, vol. 36, July 1965, p. 2278-2286. 21 refs.

Comparison in the Ar II system of calculated transition probabilities between states arising from the  $3p^4 4p$  and  $3p^4 4s$  configurations and between states of the  $3p^4 4s$  and  $3p^5$  configurations with previous theoretical and experimental work relating to the transitions as well as to laser data. It is found that the various observed laser transition thresholds between the considered configurations are in reasonable agreement with the calculations. It appears that the various upper maser states are being pumped nonuniformly. It is also found that laser action should persist to rather high current densities. It is estimated that, in 2-mm-diam. tubes, output powers of at least 10 watts/cm<sup>2</sup> of gas should be obtainable.

(Author) R.A.F.

#### A65-29805

##### STABILITY OF COUPLED-MODE LASER EQUATIONS.

J. A. Fleck, Jr. and R. E. Kidder (California, University, Lawrence Radiation Laboratory, Livermore, Calif.). *Journal of Applied Physics*, vol. 36, July 1965, p. 2327, 2328.

Correction of an equation derived from a model applicable to ruby laser "spiking." In a previous communication, the authors showed in the case of two coupled modes that the model equations possess undamped solutions, if the spatial nonuniformity of the pump source is taken into account. In the present article, it is noted that a term was omitted from one of the equations. The equation in question governs  $n'$ , the "harmonic" in the population inversion.

The corrected form of the equation is:  $dn'/dt = -n'\gamma_s + R' - Bn'(1/\gamma_1 + 1/\gamma_2)ReQ_{12} - Bn'(Q_1/\gamma_1 + Q_2/\gamma_2)$ , where  $Q_1$  and  $Q_2$  are proportional to the mode intensities,  $Q_{12}$  is an interference term, and  $B$  is a constant on the order of unity. The linearized analysis was repeated and computer runs were carried out using the corrected equation, with results and conclusions in qualitative agreement with those of the original article. Some additional results involving irregular spiking have also been obtained. These results are discussed.

R.A.F.

#### A65-29848

##### GAS LASER MEASUREMENTS OF THE ELECTRON DENSITY OF A PLASMA PRODUCED BY A VERY FAST THETA-PINCH PRE-HEATER.

A. C. C. Warnock, W. M. Deuchars, J. Irving, and D. E. Kidd (Strathclyde, University, Dept. of Natural Philosophy, Glasgow, Scotland).

*Applied Physics Letters*, vol. 7, July 15, 1965, p. 29, 30. 8 refs.

Discussion of work being done in electron density measurements in a plasma produced by a combination of radio-frequency and very fast 250-J theta-pinch discharges, using a gas laser interferometer. It is shown that in previous work, the determination of the electron density in the afterglow at any time is made from the total number of fringes appearing subsequently to that time. Such determination is dependent on the excitation or nonexcitation of transverse modes. Quinn's results are noted; they suggest that the transverse mode fringes did not occur in his experiment. In new experiments the external cavity parameters were chosen to give  $S = 3$  and  $S = 4$  and, in addition, the condition for simultaneous resonance of the laser frequencies in the external and laser cavities was taken into account. No transverse fringes were found to be produced. This is thought to be due to the fact that the  $Q$ -value of the external cavity for the 3.39- $\mu$  radiation used was low. The operation of the interferometer necessitated reflectivities on the order of 20% and 3.39  $\mu$  for the laser mirrors. The values of the electron density were calculated on the basis of the plane-mirror theory, which gives a sensitivity in this experiment of  $(3.25/L) \times 10^{-2}$  per fringe. A typical plot of the reciprocal of the number of fringes for axial observation as a function of time at a pressure of 70 mtorr is shown.

M. L.

#### A65-29849

##### TIME-DEPENDENT ELECTRON DENSITY MEASUREMENTS IN A FAST THETA-PINCH DISCHARGE.

W. M. Deuchars, D. E. Kidd, J. Irving, and A. C. C. Warnock (Strathclyde, University, Dept. of Natural Philosophy, Glasgow, Scotland).

*Applied Physics Letters*, vol. 7, July 15, 1965, p. 30-32.

Presentation of a new interferometric technique suitable for the determination of electron density variations in high-density, rapidly varying plasmas, particularly in the plasmas produced in theta-pinch discharges. A diagram of the interferometer is shown and its basic geometry is discussed. Results obtained with it in measuring the electron density on the axis during the first half-cycle (3.8  $\mu\text{sec}$ ) of a fast preheated 3.2 kJ theta-pinch are considered. The error in the absolute value of the electron density is found to be mainly due to an error in the measurement of the number of fringes and to correspond to one-quarter of a fringe.

M. L.

#### A65-29850

##### THE NATURAL SELECTION OF MODES IN A PASSIVE Q-SWITCHED LASER.

W. R. Sooy (Hughes Aircraft Co., Aerospace Group, Culver City, Calif.).

*Applied Physics Letters*, vol. 7, July 15, 1965, p. 36, 37. 7 refs. Army-supported research.

Analysis pointing out a possible explanation for the narrowing of the output spectrum of a giant pulse ruby laser which may accompany the use of a passive Q-switch and which - when combined with subsidiary mode selection - may result in a single frequency output and even total single-mode operation. It is pointed out that different modes will grow independently of each other until their combined power is sufficient to start depleting the ruby inversion. The process is nonlinear from then on, but the relative mode amplitudes that have been established at that time are indicative of

## A65-29852

which modes will appear in the output pulse. It is shown that the differentiation between two modes, in terms of loss or gain, required to suppress the weaker one is inversely proportional to the number of loop transits the signal makes in building up out of the noise. For a passive Q-switched laser, this buildup requires typically several hundred to a thousand transits, while a fast-switched laser takes only ten to several tens. This results in considerably enhanced mode selection in a passive Q-switched oscillator.

(Author) M. L.

## A65-29852

### SINGLE-MODE OPERATION OF A Q-SWITCHED RUBY LASER.

M. Hercher (Rochester University, College of Engineering and Applied Science, Institute of Optics, Rochester, N. Y.).

Applied Physics Letters, vol. 7, July 15, 1965, p. 39-41.

USAF-NSF-supported research.

Description of the general arrangement and operation of a system which includes a saturable-filter Q-switch, a specially designed resonant reflector, and a ruby laser, which makes it possible to consistently obtain emission at room temperature in a single axial mode. The spectral bandwidth of this laser emission is less than 0.001 Å (60 Mc) and is apparently limited by the pulse duration. Using a 7-cm by 0.6-cm-diameter ruby rod (0.05% doping), single-mode peak powers in excess of 5 Mw have been attained. A major feature of the single-mode Q-switched pulse is the absence of the periodic, and somewhat random, intensity fluctuations which occur when different spectral components interfere with each other. The resonant reflector is discussed in detail, and the salient features of the laser pulse obtained are presented. The corresponding laser pulse characteristics are given which were observed when the special resonant reflector was replaced by a commercially available resonant reflector and by a plane mirror with a multilayer coating.

M. L.

## A65-29867

### LASERS.

A. L. Schawlow (Stanford University, Stanford, Calif.).

(American Association for the Advancement of Science, Meeting, Cleveland, Ohio, Dec. 28, 1963, Paper.)

Science, vol. 149, July 2, 1965, p. 13-22. 81 refs.

Brief description of the general structures of lasers, and the resulting special characteristics of the radiation which they produce. In a laser, light that has a high degree of space and time coherence is obtained. Lasers are much more powerful, directional, and monochromatic than ordinary light sources. Several classes of laser are studied to see what properties can now be obtained or expected from each. Among these are optically pumped lasers, gas-discharge lasers, and semiconductor lasers. The properties of laser light are discussed at length. Many hundreds of wavelengths from less than 0.3 μ in the UV up to 0.34 mm in the far IR are now available, and peak powers exceeding 10<sup>9</sup> watts (for a few nsec) have been reported.

M. F.

## A65-29885

### LASER MEASURES CURRENT.

E. Robert Perry (Allis-Chalmers Manufacturing Co., Milwaukee, Wis.).

Instruments and Control Systems, vol. 38, July 1965, p. 123, 124.

Discussion of a laser current-monitoring device. The system uses a small air- or iron-core transformer, placed around and connected to the transmission line or bus work, as a current sensor. Information from the small current transformer feeds a solid-state pulse-coding device which modulates a gallium-arsenide laser to produce a series of coded light pulses. These pulses are transmitted by fiber optics to the control point where they are transformed into an electrical signal, amplified, and decoded to reconstruct the form of the original signal. It has been possible to match the waveform of the original current in the transmission line with a precision of better than 0.3%.

S. H. B.

## A65-29926

### GENERALIZED SOLUTIONS FOR OPTICAL MASER AMPLIFIERS.

N. Kumagai and H. Yamamoto (Osaka University, School of Engineering, Dept. of Electrical Communication Engineering, Osaka, Japan).

IEEE Transactions on Microwave Theory and Techniques, vol. MTT-13, July 1965, p. 445-451.

Study of the optical maser amplifier from the transient analysis point of view, using the Laplace-transform method. This method is considered an improvement over the conventional sinusoidal steady-state analysis that sometimes leads to inconsistent results (especially for the region beyond threshold). The wave equations are expressed in terms of Laplace transforms, and then the generalized solutions for both the transmission and the reflection mode of operation are derived taking the transient terms into account. The inverse Laplace transforms are obtained yielding the generalized solutions in terms of real-time functions. In order to emphasize the point of the argument and also to compare the results of the usual sinusoidal steady-state analysis, use is made of the simplest possible model of a one-dimensional system consisting of three media - air, active medium, and air. An incident coherent TEM wave, which falls normally on the surface of the system, is assumed. The generalized solutions derived agree, in the region below threshold, exactly with that of the sinusoidal steady-state analysis obtained previously by other investigators. However, for the region beyond critical threshold, the generalized solutions indicate that the device goes into a state of self-oscillation with oscillation frequencies that strictly coincide with those of the Fabry-Pérot-type resonator. Thus, the limitation of applicability of the conventional sinusoidal steady-state analysis is clarified. Some remarks are also given on the design problem of optical maser amplifiers in connection with the transient terms involved.

(Author) M. F.

## A65-29936 #

### PHOTOGRAPHING SATELLITE-REFLECTED LASER PULSES FOR GEODETIC STEREO TRIANGULATION.

Robert L. Liff (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Bedford, Mass.).

Journal of Geophysical Research, vol. 70, July 15, 1965, p. 3505-3508.

Determination of the angular position of a satellite relative to a laser station from photographic data. If range data from an optical radar-illuminator are also provided, the position of a satellite in space is uniquely determined. Successfully recorded images demonstrate the feasibility of using lasers to illuminate specially equipped satellites for geodetic triangulation. The equipment used in this feasibility experiment should be modified to permit illuminating the satellite several times per pass to eliminate possible position determination errors due to atmospheric "seeing." A ruby laser with a 250-joule output, an array of corner reflectors on Explorer 22 (1964 64A), an EMI 9558B photomultiplier in a 12-cm refracting telescope, and a PC-1000 geodetic stellar camera were used in the feasibility study.

M. F.

## A65-29974

### WIDE-BAND MODULATION OF A LASER BEAM, USING BRAGG-ANGLE DIFFRACTION BY AMPLITUDE-MODULATED ULTRASONIC WAVES.

Harold V. Hance and J. K. Parks (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Research and Development Laboratories, Palo Alto, Calif.).

Acoustical Society of America, Journal, vol. 38, July 1965, p. 14-23. 21 refs.

Research supported by the Lockheed Independent Research Program.

Theoretical study of how modulation bandwidth can be maximized by converging the incident light beam to a focus to minimize beam diameter and by confining the ultrasonic beam to the vicinity of the focal plane. Light valves based on the ultrasonic-diffraction effect are capable of producing high-index intensity modulation of a light beam, but they are subject to a fundamental bandwidth limitation associated with the finite time of transit of an ultrasonic wave across the light beam. Under properly chosen conditions, modulation bandwidth can be as large as 1/7.7 times the ultrasonic carrier frequency. An experimental investigation was carried out using water as the ultrasonic medium to verify the theoretical dependence of modulation bandwidth on ultrasonic- and optical-beam parameters and to evaluate constants of the theory. The experiments also showed that the wavefronts near the focus of a convergent light beam are sufficiently plane to produce Bragg-type diffraction when conditions are otherwise favorable. Bragg diffraction was used in the modulation bandwidth measurements. The dependence of diffracted-beam intensity on ultrasonic amplitude was investigated experimentally and, in accordance with theory, it was found that nearly all of the incident

(zero-order) light can be transferred to a selected first-order diffracted beam. This fact permits either the zero-order or a first-order beam to be chosen as the useful output of the modulator.

(Author) M. F.

#### A65-29978 #

##### THE PRODUCTION OF HIGH TEMPERATURE PLASMAS BY INTENSE LASER PULSES.

B. A. Tozer, P. R. Smy, and J. K. Wright (Central Electricity Generating Board, Research Laboratories, Leatherhead, Surrey, England).

*Physical Society, Proceedings*, vol. 86, July 1965, p. 45-51. 8 refs.

Consideration of the possibility of producing dense high-temperature plasmas by heating magnetically contained plasma with a pulsed laser beam. The process requires high ion densities ( $> 10^{17} \text{ cm}^{-3}$ ) to be maintained during the heating period, and the magnetic field strength required to contain such a plasma has been calculated in terms of both the kinetic pressure and Bohm diffusion of the plasma. Radiation and conduction losses from the plasma are also considered, and it is concluded that temperatures of the order of  $10^6 \text{ K}$  should be obtainable within present-day limits of field strength and photon flux. To attain the conditions necessary for a fusion reactor with net power output, using a hydrogen isotope, laser energies greater than  $10^4$  joules for a single passage of the radiation through the plasma and magnetic field strengths greater than  $10^8$  gauss are required if the plasma is formed from a hydrogen pellet in vacuo. The magnetic field strength has been calculated on the assumption that Bohm diffusion will be the most severe plasma loss mechanism. If the plasma is formed in a gas, a total laser energy of greater than  $10^{11}$  joules is required at a power greater than  $10^{18}$  watts. Any possible future development of a high-powered UV laser will make the use of high magnetic fields unnecessary, provided sufficiently short laser pulses can be obtained. In this case there is no difference between the results obtained for the vacuum- or gas-encased model. In each case laser energies greater than  $10^6$  joules at powers greater than  $10^{15}$  watts are required. The vacuum-encased model, with strong magnetic field, is identical with that at ruby laser frequencies.

(Author) B. B.

#### A65-30070 #

##### THE LOCK-ON BAND OF A LASER OSCILLATOR [POLOSA ZAKHVAITYVANIA CHASTOTY LAZERNOGO GENERATORA].

I. L. Bershtein (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

*Akademiia Nauk SSSR, Doklady*, vol. 163, July 1, 1965, p. 60-62. In Russian.

Determination of the lock-on band of a continuously operating laser oscillator. The analysis is said to be valid for the case of a sufficiently small external force (and consequently lock-on band). A traveling-wave laser-oscillator circuit containing three reflecting mirrors and one active element is considered. Although the formula for the lock-on band is obtained under the assumption that only one traveling wave is present, it is thought that this formula will remain valid for the case of two oppositely traveling waves and for the case of an ordinary standing-wave laser oscillator.

A. B. K.

#### A65-30071 #

##### ESTIMATE OF THE ENERGY PARAMETERS OF THE WELDING OF METALS BY A LASER LIGHT BEAM [OTSENKA ENERGETICHESKIKH PARAMETROV SVARKI METALLOV SVETOVYM POTOKOM LAZERA].

N. N. Rykalin and Iu. L. Krasulin (Akademiia Nauk SSSR, Institut Metallurgii, Moscow, USSR).

*Akademiia Nauk SSSR, Doklady*, vol. 163, July 1, 1965, p. 87-90. 6 refs. In Russian.

Consideration of various schemes for obtaining a rough estimate of the energy parameters of a laser light beam, in order to prevent vaporization of a metal surface when such a beam is used for welding. An attempt is made to estimate not only the maximum permissible power of an entire pulse but also that of an individual burst of energy. The problem is solved for the case of the interaction between a light beam and the surface of a semi-infinite heat-conducting body.

A. B. K.

#### A65-30204 #

##### USE OF LIDAR IN ATMOSPHERIC RESEARCH.

Ronald T. H. Collis (Stanford Research Institute, Menlo Park, Calif.).

*American Institute of Aeronautics and Astronautics, Annual Meeting*, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-464. 8 p. 8 refs.

Members, \$0.50; nonmembers, \$1.00.

Research sponsored by Lear Siegler Corp. and Navy.

Explanation of the LIDAR (light detection and ranging) technique and its application to the study of meteorological factors which are important to aviation and rocket operations in the atmosphere. LIDAR is the optical counterpart of microwave radar and employs a giant-pulsed laser as its power source. Investigations of clouds, discontinuities in clear air, and air motion using LIDAR are discussed.

S. H. B.

#### A65-30303

##### MODE COMPETITION AND FREQUENCY SPLITTING IN MAGNETIC-FIELD-TUNED OPTICAL MASERS.

R. L. Fork (Bell Telephone Laboratories, Inc., Murray Hill, N. J.) and M. Sargent, III (Yale University, New Haven, Conn.).

*Physical Review, 2nd Series, Section A*, vol. 139, Aug. 2, 1965, p. A617, A618. 6 refs. USAF-supported research.

Equations describing the beat-frequency variation and mode competition in a gaseous optical maser operated in a magnetic field parallel to the maser axis. The equations include only lowest-order nonlinear terms. Important terms in the amplitude- and frequency-determining equations are shown to arise from an induced atomic precession. These terms have a character similar to those describing the effects of selective depletion of the velocity distribution or "hole burning." It is shown that the induced atomic precession causes parametric conversion of an optical field of one circular polarization into an optical field of the other polarization, with a frequency shift equal to the rate of precession. This process tends to make the competition between modes of different polarizations important. An additional feature, not found in the scalar theory, is that, for sufficiently large magnetic fields, competition can be important between modes separated in frequency by several Doppler-broadened linewidths.

(Author) R. A. F.

#### A65-30330

##### SILICON-CONTROLLED-RECTIFIER LONG-PULSE DRIVER FOR INJECTION LASERS.

M. C. Teich, D. A. Berkley, and G. J. Wolga (Cornell University, Ithaca, N. Y.).

*Review of Scientific Instruments*, vol. 36, July 1965, p. 973, 974. ARPA-supported research.

Brief discussion of the design and operation of a pulser capable of driving injection lasers with long pulses ( $> 30 \mu\text{sec}$ ), high duty cycle, and currents of up to 20 amp. Higher currents may be obtained by increasing the power capabilities of the circuit components. Special features of the pulser are its low cost, simplicity of construction, and laser overload protection.

(Author) B. B.

#### A65-30333

##### ANALYSIS OF GAS PRESSURE AND COMPOSITION IN A HELIUM-NEON LASER DISCHARGE.

R. Turner and C. J. Van der Hoeven (National Research Council, Div. of Applied Physics, Ottawa, Canada).

*Review of Scientific Instruments*, vol. 36, July 1965, p. 1003-1005.

Description of a method of analyzing the gas constitution of a He-Ne laser discharge. The laser tube was of quartz and consisted of a capillary with a bore of 2 mm and length of 18 cm; it had a 25-mm-diam cylindrical bulb at each end into which were sealed reflectors consisting of multilayer dielectric coatings on quartz plugs. The analysis is made in terms of the relative intensities of three spectrum lines in the light emitted from the side of the laser discharge tube. A graph is given relating these intensities to the laser gas constitution and also to the laser output power. Results on gas clean-up and relative laser output power during the lifetime of a helium-neon laser are also included.

B. B.

**A65-30342**

REDUCTION OF INFRARED MASER LOSSES BY CAVITY TUBING.  
J. A. Little and C. V. Heer (Ohio State University, Dept. of Physics, Columbus, Ohio).  
*Review of Scientific Instruments*, vol. 36, July 1965, p. 1061.  
Grant No. NSG 552.

Observation that the power level of oscillation of a 3.39- $\mu$  He-Ne IR maser depends on the bore of the tubing used in the maser cavity. The maser configuration is a 92 x 92 cm Fabry-Pérot square cavity in which is mounted a 6-mm-ID He-Ne discharge tube with Brewster angle windows. A 75% increase in the power level of oscillation was observed when a 75-cm length of 6-mm-bore Pyrex tube was inserted into one leg of the cavity. An explanation for the observed phenomenon is given in terms of the coefficient of reflection for almost grazing incidence.

B. B.

**A65-30343**

## SPECTROSCOPY OF ION LASERS.

William B. Bridges and Arthur N. Chester (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).  
*IEEE Journal of Quantum Electronics*, vol. QE-1, May 1965, p. 66-84. 63 refs.

Brief discussion of the history of laser oscillation in gaseous ions, including a tabulation of wavelengths, classifications, and references for the 230 reported ion laser transitions. It is shown that the strongest laser lines are also the strong lines observed in spontaneous emission. Selection rules and excitation mechanisms yielding oscillation are discussed.

(Author) D. P. F.

**A65-30344**

## DESIGN CONSIDERATIONS FOR MODE SELECTIVE FABRY-PÉROT LASER RESONATOR.

N. Kumagai, M. Matsuhara, and H. Mori (Osaka University, School of Engineering, Dept. of Electrical Communication Engineering, Osaka, Japan).  
*IEEE Journal of Quantum Electronics*, vol. QE-1, May 1965, p. 85-94. 15 refs.

Development of a theory for mode-selective multireflector Fabry-Pérot laser resonators. A practical design problem to achieve the maximum discrimination against unwanted modes is solved. The laser resonators under consideration are expressed entirely in terms of an equivalent electric circuit and treated mathematically on the basis of classical circuit theory. The expression determining both the oscillation frequencies and the minimum gain required to maintain steady oscillations is derived. The effects of mirror spacing and reflectivities on mode selectivity are shown. A numerical example shows that a helium-neon gas laser consisting of a four-reflector resonator can exhibit an appreciable suppression of spurious oscillations in all unwanted axial modes by suitable choice of parameters.

(Author) D. P. F.

**A65-30345**

## LONGITUDINAL MODE CONTROL IN GIANT PULSE LASERS.

F. J. McClung and D. Weiner (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).  
*IEEE Journal of Quantum Electronics*, vol. QE-1, May 1965, p. 94-99. 6 refs.

Description of techniques for obtaining longitudinal mode selection in a giant pulse laser resulting in single-mode output from the laser. Some advantages of achieving longitudinal mode control in a giant pulse laser are noted. The methods of mode control used are described. These include orienting various reflecting surfaces in the laser cavity, cooling the ruby laser crystal, and introduction of a saturable dye in the cavity. Methods of measuring the mode structure are given. Results of these measurements with varying degrees of mode control are described in detail. Under some conditions it is possible to obtain essentially single-mode behavior from the giant pulse laser.

(Author) D. P. F.

**A65-30346**

ELECTRON BEAM PUMPED LASERS OF PbS, PbSe, and PbTe.  
C. E. Hurwitz, A. R. Calawa, and R. H. Rediker (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).  
*IEEE Journal of Quantum Electronics*, vol. QE-1, May 1965, p. 102, 103. 13 refs.

Observations of laser action at liquid-helium temperature in crystals of PbSm, PbSe, and PbTe excited by a beam of fast electrons. The samples were prepared by cleaving rectangular parallelepipeds of the materials and alloying them with indium to the cold finger of a liquid-helium Dewar. The optical cavity was formed by two parallel faces perpendicular to the face on which the electron beam was incident, and the radiation was emitted normal to the beam. Laser action was achieved in all three materials for electron energies from 19 to 60 keV. The onset of laser action occurs at about 3.5  $\mu$ ; at 40  $\mu$  the curve approaches a linear relationship, indicating a possible limit in the quantum efficiency. Emission spectra showing the mode structure of the laser lines are illustrated.

D. P. F.

**A65-30347**

## THRESHOLD DEPENDENCY ON REABSORPTION LOSS IN INJECTION LASERS.

M. F. Lamorte, H. Junker, and T. Gonda (Radio Corporation of America, RCA Electronic Components and Devices Div., Somerville, N.J.).

*IEEE Journal of Quantum Electronics*, vol. QE-1, May 1965, p. 103, 104.

Contract No. DA-44-009-AMC-99(T).

Hypothesis that reabsorption is the dominant loss mechanism for both incoherent and coherent radiation in GaAs luminescent diodes. Degenerate junctions were fabricated by means of an epitaxial technique for which the donor concentration is  $Z \times 10^{18}$  cm<sup>3</sup>. The laser structure was constructed by cleaving all four sides. Threshold and laser wavelengths were obtained under pulsed conditions for pulse lengths of 0.2  $\mu$  sec at 77 and 300°K. There is a table illustrating the threshold, photon energy, and the absorption coefficients for these two temperatures. The light-emitting layer thickness is assumed to be 10  $\mu$ ; the resulting equivalent absorption coefficient is 7 cm<sup>-1</sup>. The equivalent absorption coefficient for the transmission loss is added to this value.

D. P. F.

**A65-30372**

## SYNCHRONIZATION OF OSCILLATIONS IN A SEMICONDUCTING LASER HAVING SEVERAL p-n JUNCTIONS.

N. G. Basov, E. M. Belenov, and V. S. Letokhov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Fizika Tverdogo Tela, vol. 7, Jan. 1965, p. 337-339.)

*Soviet Physics - Solid State*, vol. 7, July 1965, p. 275, 276. 5 refs.

Translation.

[For abstract see Accession no. A65-17319 07-16]

**A65-30377**

## MASERS AND THEIR PRESENT POSSIBILITIES [LES MASERS ET LEURS POSSIBILITES ACTUELLES].

M. Soutif (Grenoble, Université, Faculté des Sciences, Grenoble, France).

*L'Onde Electrique*, vol. 45, Jan. 1965, p. 41-52. 15 refs. In French.

Description of the principles on which maser operation is founded together with practical design considerations and some current applications. The factors prevalent in a two-level energy system in equilibrium are described. The interaction between an electromagnetic wave and a two-level system which modifies the particle density at either level by causing a transition of such particles from one level to the other is affected by several phenomena - (1) absorption, (2) stimulated emission, and (3) spontaneous emission. It is shown that the equilibrium established between absorption and emission can be affected by pumping phenomena and that this requires a three-level energy system. The maser effect is due to the fact that with negative temperatures an incident wave will cause greater stimulated emission than absorption. The operation of three-level maser devices is described, followed by a description of their application to the amplification of microwaves in the field of telecommunications.

D. P. F.

**A65-30378**

PROBLEM OF MEASURING THE CHARACTERISTICS OF A MASER WITH RESPECT TO ITS NOISE TEMPERATURE AND STABILITY [PROBLEME DE MESURE DES CARACTERISTIQUES D'UN MASER AU POINT DE VUE DE SA TEMPERATURE DE BRUIT ET DE SA STABILITE].

M. J. Grangeon (Compagnie Française Thomson-Houston, Centre de Recherches, Service d'Etudes Techniques Avancées, Bagneux, Seine, France).

*L'Onde Electrique*, vol. 45, Jan. 1965, p. 53-59. In French.

Technique for measuring the noise temperature of a maser which considers the gain stability characteristics and the bandpass width of the device. The measurements were made on a cavity-type maser utilizing a ruby as the paramagnetic crystal. The equipment consisted of a cold charge, an input waveguide, a signal generator, a circulator, a helium-cooled maser cavity, a source of i.f., and a mixer; the output was fed into a superheterodyne amplifier operating at 36 Mc. Measurements were made on the output side of a quadratic detector. After the signal had been amplified by the superheterodyne. The measurements enabled the noise temperature of the maser to be determined as well as the effective bandpass of the device. The results are analyzed mathematically. D. P. F.

#### A65-30436

##### LASER PUMPING BY ELECTRON PHOSPHORS.

J. O. Ogland and C. W. Baugh, Jr. (Westinghouse Electric Corp., Aerospace Div., Defense and Space Center, Baltimore, Md.).  
*Research/Development*, vol. 16, Aug. 1965, p. 22-25.

Investigation of the use of cathodoluminescent phosphors as a light source for lasers which will reduce ultimate heat limitations and eliminate internal stresses caused by thermal gradients. The emission spectrum of P20 phosphor approximately matches the absorption spectrum of a glass neodymium laser. A pump, consisting of a phosphor-coated closed-end quartz pipe protruding into a vacuum chamber, was constructed to test the feasibility of cathodoluminescent laser pumping. Four amplifier tubes, modified to perform as flood guns, surround the quartz pipe and produce a uniform electron excitation of the phosphor. An aluminum coating of the phosphor provided the electrical connection and acted as an optical reflector for trapping the light inside the quartz pipe. Pulses up to 700  $\mu$ sec long were produced. A proposed design for a continuous-operation laser employing this pumping system is described, and coupling and power considerations are discussed.

S. H. B.

#### A65-30510 \*

##### THE QUANTUM MECHANICS OF SIGNALS AND NOISE IN ATTENUATORS AND MASER AMPLIFIERS.

F. N. H. Robinson (Oxford, University, Clarendon Laboratory, Oxford, England).

*Royal Society (London), Proceedings, Series A*, vol. 286, Aug. 3, 1965, p. 525-536. 5 refs.

Application of a method used by Gordon, Walker, and Louisell (1963) to treat the temporal behavior of signals and noise to obtain their spatial or steady-state behavior in a lossy line or attenuator and a maser amplifier. The results relate the expectation values of the output voltage and its power spectrum to a classical signal input and the thermal state of the system. They differ in principle but not in practice from the results obtained by classical arguments. (Author) M. F.

#### A65-30519 \*

##### COMMUNICATION REQUIREMENTS BETWEEN MANNED SPACECRAFT ON INTERPLANETARY VOYAGES.

R. B. Marsten, D. Silverman, and S. Gubin (Radio Corporation of America, Princeton, N. J.).

*American Institute of Aeronautics and Astronautics, Annual Meeting, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-324.* 8 p. 10 refs.

Members, \$0.50; nonmembers, \$1.00.

Influence of the mission and systems problems on the performance required of lasers and microwaves to satisfy the communications requirements of a multivehicle, manned Mars mission. The laser has the potential to support 1000 times the signaling bandwidth of a microwave system, and its transmission bandwidth can theoretically be smaller than one  $\mu$ rad, whereas the narrowest transmission bandwidth for a microwave system is about a mrad. It is considered that the communications requirements would include high-quality, commercial-rate duplex television links for the spacecraft links and the squadron-to-earth links. For the earliest missions, wideband laser communications between spacecraft are necessary.

For transmission to the earth, it is believed that neither lasers nor microwaves will be adequate until the problems of higher powered lasers and on-board offset lead angle computation are solved.

F. R. L.

#### A65-30540

##### LASER BEAM MACHINING.

N. Forbes (Ferranti, Ltd., Edinburgh, Scotland).

(Symposium on Electron Beam Techniques for Microelectronics, Ministry of Aviation, Royal Radar Establishment, Malvern, Worcs., England, July 6-8, 1964, Paper.)

*Microelectronics and Reliability*, vol. 4, Mar. 1965, p. 105-108.

Account of the use of solid state and gas lasers for the machining of thin films and for cutting, drilling, and welding operations. Illustrations show transistor lead and thermocouple wire weldments, drilled aluminum and steel blocks, and machined surfaces of gold and nichrome films. A schematic diagram of an engineered welding and drilling machine is included. B. B.

#### A65-30572

##### STUDY OF THE "LASER" EFFECT IN GALLIUM ANTIMONIDE JUNCTIONS [ETUDE DE L'EFFET "LASER" DANS DES JONCTIONS D'ANTIMONIURE DE GALLIUM].

C. Chipaux and R. Eymard (Centre National d'Etudes des Télécommunications, Issy-les-Moulineaux, Seine, France).

*Physica Status Solidi*, vol. 10, no. 1, 1965, p. 165-174. 11 refs. In French.

Study of recombination radiation from gallium antimonide p-n junctions grown from the melt. Stimulated emission and laser action are observed at 78 and 50°K. One of the diodes has a threshold current density of 300 amp/cm<sup>2</sup> at liquid-helium temperature and shows continuous laser action. The observed mode structure corresponds to  $n - \lambda (dn/d\lambda) \approx 4$ . By means of an IR image converter, filamentary emission is observed for diodes operated above the threshold. The peak of the laser emission is found to lie at 0.775, 0.790, and 0.800 eV for different diodes. One particular junction displays simultaneous laser action at 0.790 and 0.800 eV.

(Author) M. F.

#### A65-30574

##### RELAXATION OSCILLATIONS IN A FOUR-LEVEL SOLID-STATE LASER.

M. Chomát (Czechoslovak Academy of Sciences, Institute of Radio-engineering and Electronics, Prague, Czechoslovakia).

*Physica Status Solidi*, vol. 10, no. 1, 1965, p. 185-191. 12 refs.

Study of a system of differential equations for the nonlinear four-level laser problem. The shape and envelope of the relaxation oscillations are derived. The influence of the time-dependent intensity of the excitation on the character of the transient processes is investigated. These results are compared with the results obtained by using an analog computer. (Author) M. F.

#### A65-30594

##### PROGRESS IN SEMICONDUCTOR LASERS.

Benjamin Lax (Massachusetts Institute of Technology, National Magnet Laboratory, Lexington, Mass.).

*IEEE Spectrum*, vol. 2, July 1965, p. 62-75. 55 refs.

Summary of the recent developments in the field of semiconductor lasers. A brief history, basic principles, and recent developments in the field are outlined, and magnetic effects and applications are discussed. About a dozen new materials have emerged as effective media for generating coherent radiation in the IR from about 0.6 to 8.5  $\mu$ . Levels of several watts of continuous power and about 1 kw of peak power in short pulses have been attained. However, many problems remain to be solved in the theoretical, experimental, and technological areas. When better or properly controlled materials are developed in the high-gap region, optical lasers will become possible; holography (a new lensless, three-dimensional photographic method employing coherent light) will then become more convenient and useful. B. B.

#### A65-30792

##### PLASMA COMPRESSION BY LIGHT PRESSURE.

A. Caruso and F. Gratton (EURATOM and Comitato Nazionale per l'Energia Nucleare, Laboratorio Gas Ionizzati, Frascati, Italy).

*Nuclear Fusion*, vol. 5, Mar. 1965, p. 87, 88. 6 refs.



Description of the production of high-temperature and high-density plasmas by focusing giant laser pulses on small specks of solid materials, such as deuterium. The power of such laser beams is in the  $10^{17}$ -erg/sec range and the linear dimension of the material to be converted to plasma is approximately  $10^{-3}$  cm. For electro-magnetic energy densities greater than a few multiples of  $10^{10}$  erg/cm<sup>3</sup>, the ionization is mainly due to the direct action of the electric field of the wave (a tunnel effect). To calculate this effect the formulas deduced in quantum mechanics for the ionization due to a constant field may be used, since the light frequency is smaller than the Bohr fundamental frequency. For lasers with a light amplifier, the rise time of the pulse is smaller than the duration of the pulse. The properties of a plasma formed by giant laser pulses are tabulated. D. P. F.

**A65-30797 \*****THE THEORY OF Q-SWITCHING APPLIED TO SLOW SWITCHING AND PULSE SHAPING FOR SOLID STATE LASERS.**

J. E. Midwinter (Ministry of Aviation, Royal Radar Establishment, Great Malvern, Worcs., England).  
*British Journal of Applied Physics*, vol. 16, Aug. 1965, p. 1125-1133. 9 refs.

Solution by computer of the rate equations derived by Vuytsteke for the growth and decay of photon flux and population inversion within the laser resonator. Slow switching, simulating the rotating mirror switch, has been studied and new conclusions drawn. Pulse shaping has also been treated, and the switching functions necessary to produce square-topped output pulses have been derived. Detailed solutions are also given for a fast step-function switch. (Author) M. F.

**A65-30800 \*****THE EFFECTS OF OXYGEN ON THE PROPERTIES OF CaF<sub>2</sub> AS A LASER HOST.**

P. A. Forrester, G. W. Green, and D. F. Sampson (Ministry of Aviation, Royal Radar Establishment, Great Malvern, Worcs., England).  
*British Journal of Applied Physics*, vol. 16, Aug. 1965, p. 1209, 1210. 6 refs.

Questioning of the widely held view that the presence of oxygen degrades the performance of CaF<sub>2</sub> laser systems. Oxygen has been thought to be the cause of optical loss due to scattering and also to be responsible for the conversion of deliberately added impurities from the desired divalent state into higher valence states. These two beliefs are not supported by the present observations (1) of the absence of scatter loss in CaF<sub>2</sub> containing up to 100 ppm of CaO, and (2) of optical maser action from Sm<sup>++</sup> ions in crystals grown from a melt containing Sm<sub>2</sub>O<sub>3</sub>. (Author) M. F.

**A65-31002****NOISE IN LASERS AND LASER DETECTORS.**

Arnold L. Bloom.

*Spectra-Physics Laser Technical Bulletin*, no. 4, 1965. 10 p. 8 refs.

Noise properties of the laser amplifier and the conventional laser oscillator, sources of noise not associated with fundamental or thermal effects, and the low-noise heterodyne detector. The discussion is based primarily on applications of the helium-neon laser oscillating at 6328 Å, although most of the formulations apply equally well to other types of gas-discharge lasers. Fundamentals are reviewed, followed by discussion of the properties of the laser amplifier and the noise output of gas laser oscillators. The heterodyne detector, consisting of (1) the local oscillator, (2) the photocell, and (3) a device for superimposing images of the local oscillator and the received signal on the photocell, is described. It is shown that the laser amplifier should have a noise level 10 times greater than theoretical, while the heterodyne detector has a noise level approximately  $\sqrt{10}$  times theoretical or greater. F. R. L.

**A65-31032****NOISE PERFORMANCE OF AN OVERLOADED MASER AMPLIFIER.**

Dietrich Marcuse (Bell Telephone Laboratories, Inc., Holmdel, N. J.).

*IEEE, Proceedings*, vol. 53, July 1965, p. 687-692. 6 refs.

Study of the noise output and noise factor F of a simplified model of a maser as a function of the ratio g/G of small-signal gain g to actual gain G. Although the noise output is found to

decrease rather sharply as g/G is increased, the noise factor increases only very slowly from its value of F = 1 at g/G = 1 to F =  $1 + 1/2 \ln g$  for a totally overloaded maser (G = 1). (Author) A. B. K.

**A65-31034****STATISTICS OF THERMAL AND LASER RADIATION.**

Henri Hodara (National Engineering Science Co., Pasadena, Calif.).  
*(WESTERN ELECTRONIC SHOW AND CONVENTION, LOS ANGELES CALIF., AUGUST 25-28, 1964, TECHNICAL PAPERS. VOLUME 8. PART III - ELECTRON DEVICES, COMPONENT PARTS, p. 17.4-1, 17.4-2.)*

*IEEE, Proceedings*, vol. 53, July 1965, p. 696-704. 23 refs.

**A65-31044****Q-SWITCHED LASER BEAM PROPAGATION OVER A TEN-MILE PATH.**

J. R. Whitten, G. F. Prehmus, and K. Tomiyasu (General Electric Co., Schenectady, N. Y.).

*IEEE, Proceedings*, vol. 53, July 1965, p. 736.

Photographic study of a Q-switched laser beam propagating over a 10-mile path. Certain similarities are noted in the pictures taken, the light often appearing in small spots the diameters of which range from about 1/2 to 1-1/4 in. In rare instances arcs of light appear with a width of about 1/2 in. and a radius of about 2 to 3 in. It is estimated that the range in brightness over the area of the screen may be as much as 40 db or greater. A. B. K.

**A65-31220****OPTICAL HARMONIC GENERATION IN SEMICONDUCTORS AND IN DIELECTRICS CLOSE TO AN ABSORPTION BAND EDGE.**

A. M. Afanas'ev and E. A. Manykin (Moskovskii Inzhenerno-Fizicheskii Institut, Moscow, USSR).

*(Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Feb. 1965, p. 483-487.)*

*Soviet Physics - JETP*, vol. 21, Aug. 1965, p. 323-325. 5 refs. Translation.

[For abstract see Accession no. A65-21056 11-26]

**A65-31235****ON THE STATISTICS OF LASER EMISSION.**

V. S. Letokhov and E. P. Markin (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*(Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Feb. 1965, p. 770, 771.)*

*Soviet Physics - JETP*, vol. 21, Aug. 1965, p. 509, 510. Translation.

[For abstract see Accession no. A65-21070 11-16]

**A65-31236****THE CHANGE IN THE EMISSION CHARACTERISTICS OF A RUBY LASER CAUSED BY PHTHALOCYANINE SOLUTIONS IN THE LASER CAVITY.**

V. N. Gavrilov, Iu. M. Gрязнов, O. L. Lebedev, and A. A. Chastov.

*(Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, Feb. 1965, p. 772, 773.)*

*Soviet Physics - JETP*, vol. 21, Aug. 1965, p. 510, 511. Translation.

[For abstract see Accession no. A65-21071 11-16]

**A65-31306 \*****SPECTRAL CHARACTERISTICS OF A GASEOUS TRAVELING-WAVE LASER [SPEKTRAL'NYE KHARAKTERISTIKI GAZOVOGO LAZERA S BEGUSHCHEI VOLNOI].**

S. N. Bagaev, V. S. Kuznetsov, Iu. V. Troitskii, and B. I. Troshin (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Institut Fiziki Poluprovodnikov, USSR).

*ZHETF Pis'ma v Redaktsiiu*, vol. 1, May 15, 1965, p. 21-24. In Russian.

Experimental investigation of the spectral properties of an He-Ne traveling-wave laser operating on the wavelength  $\lambda = 6328 \text{ \AA}$ . Referring to a paper by Tang, Statz, deMars, and Wilson in which it was shown that a ruby TW laser oscillates in a single mode because the  $R_1$  line of the ruby is homogeneously broadened at room temperature, an investigation was made to determine whether an additional decoupling of longitudinal modes can arise because of the difference in position of the nodes and antinodes in the mode field of a traveling-wave resonator. It is found that by eliminating the spatial field nonuniformities in the resonator it is possible to strengthen appreciably the coupling between the different oscillation types, even in the case of inhomogeneous line broadening, and to obtain powerful emission at 1 to 2 longitudinal modes. V. P.

#### A65-31397 #

GENERATION OF GaAs TWO-PHOTON OPTICAL OSCILLATIONS BY Nd-GLASS-LASER RADIATION [GENERATSIIA V GaAs PRI DVUKH FOTONNOM OPTICHESKOM VOZBUZHDENII IZLUCHE-NIEM OKG NA NEODIMOVOM STEKLE].

N. G. Basov, A. Z. Grasiuk, I. G. Zubarev, and V. A. Katulin (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). *ZHETF Pis'ma v Redaktsiiu*, vol. 1, May 15, 1965, p. 29-33. In Russian.

Experimental investigation showing the possibility of exciting GaAs by an Nd-glass-laser in the case in which the pumping-photon energy (1.17 eV,  $\lambda = 1.06 \mu$ ) was much less than the width of the forbidden band in GaAs (1.51 eV,  $\lambda = 8200 \text{ \AA}$ , at  $T = 77^\circ\text{K}$ ). In this case, the energy of one exciting photon is insufficient for the transition of an electron from the valence band to the conduction band. It is seen that at high luminous densities, excitation becomes possible because of the presence of nonlinear optical effects, such as two-photon absorption or absorption of the pumping-light harmonic that forms in the semiconductor. V. P.

#### A65-31375 #

INVESTIGATION OF SOME CHARACTERISTICS OF A HELIUM-NEON LASER [ISSLEDOVANIIE NEKOTORYKH KHKARAKTERISTIK GELII-NEONOVOGO LAZERA].

F. A. Korolev, A. I. Odintsov, and V. N. Mitsai.

*Optika i Spektroskopiia*, vol. 19, July 1965, p. 71-77. 6 refs. In Russian.

Experimental investigation of the power generated at the line  $6328 \text{ \AA}$  as a function of (dc) discharge-current strength, the pressure of the He-Ne mixture, and the partial pressures of He and Ne. It is found that for each of these discharge parameters the generated power has a maximum, the position and magnitude of which depends on the other parameters. The effect of resonator-mirror spacing on the generated power at constant gap length is investigated, as is the spectral composition of laser radiation, using a Fabry-Pérot interferometer. Good agreement with theory is found for both a confocal and nonconfocal resonator. V. P.

#### A65-31376 #

SOME LASER PROPERTIES FROM THE VIEWPOINT OF THERMODYNAMICS [NEKOTORYE SVOISTVA OPTICHESKIKH KVANTOVYKH GENERATOROV S TOCHKI ZRENIIA TERMODINAMIKI].

Iu. T. Mazurenko.

*Optika i Spektroskopiia*, vol. 19, July 1965, p. 156-158. In Russian.

Analytical investigation of the generation of stimulated emission on the basis of the second law of the thermodynamics of irreversible processes. An expression is derived for the efficiency of a system with optical pumping generating directional monochromatic radiation and for a system with optical pumping in which both generation and pumping are associated with single-quantum transitions. V. P.

#### A65-31383

PRODUCTION OF COHERENT RADIATION BY ATOMS AND MOLECULES (1964 Nobel Lecture).

Charles H. Townes (Massachusetts Institute of Technology, Cambridge, Mass.).

(Nobel Foundation, Lecture, Stockholm, Sweden, Dec. 11, 1964.)

*IEEE Spectrum*, vol. 2, Aug 1965, p. 30-43. 65 refs.

Review of the successive ideas and theoretical thinking that led to the development of the maser and laser. The use of thermodynamic arguments is recapitulated. Basic maser principles are analyzed, and it is pointed out that the crucial requirement for the generation of coherent radiation (recognized by Townes and also by Basov and Prokhorov) was to produce positive feedback by some resonant circuit and to ensure that the gain in energy afforded the wave was greater than the circuit losses. Maser clocks and amplifiers, optical and infrared masers, or lasers, including ruby, gaseous, and semiconductor lasers, are considered. Lasers are evaluated by comparing their actual performance with the theoretical expectation. Three areas of application of lasers are discussed: measurement of the two fundamental dimensions of time and length by means of an ultra-accurate determination of the velocity of light; increased power of spectroscopy; and nonlinear optics, including the interaction of light with the medium through which it travels. It is shown that the laser now makes it possible to produce and study the behavior of vhf acoustic waves in almost any transparent material. M. L.

#### A65-31408 #

PARAMAGNETIC MASER AMPLIFIERS.

V. B. Shteinsheleger and S. V. Dedkov.

*(Radiotekhnika)*, vol. 19, Nov. 1964, p. 5-18.)

*Telecommunications and Radio Engineering. Radio Engineering*, vol. 19, Nov. 1964, p. 67-76. 66 refs. Translation.

#### A65-31451

MECHANISM OF POPULATION INVERSION AT  $6149 \text{ \AA}$  IN THE MERCURY ION LASER.

D. J. Dyson (Ferranti, Ltd., Valve Dept., Edinburgh, Scotland). *Nature*, vol. 207, July 24, 1965, p. 361-363.

Research supported by the Ministry of Defence.

Description of results of the observation of the time-variation of the spontaneous emission from a helium-mercury discharge which appear to clarify the mechanism responsible for excitation of the  $6149\text{-\AA}$  laser transition in this system. The decay rate characterized by the decaying edge of the  $6149\text{-\AA}$  emission pulse was found to be sensitive to the discharge tube temperature which controls the mercury vapor pressure, rather than to the helium pressure. Measurements were made with a discharge tube 2.3 cm in diameter and approximately 1 m in length. The discharge condenser was 1000 pf and the charging voltage 8 kv. Helium pressure was about 5 torr. The only excited species capable of raising the ground-state mercury atom to the upper level of the  $6149\text{-\AA}$  transition is the helium ion. D. P. F.

#### A65-31455

REDUCED ABSORPTION OF LIGHT AT HIGH LASER POWER DENSITIES.

Hubertus Staerk and Georg Czerlinski (Pennsylvania, University, Johnson Research Foundation, Philadelphia, Pa.).

*Nature*, vol. 207, July 24, 1965, p. 399, 400. 6 refs.

Contract No. Nonr-551 (46).

Experimental results and analysis of the photobleaching effect observed in the absorption of coherent light from lasers by methylene blue. The  $633\text{-\mu}$  line of a He-Ne-CW laser was used for the experiments. The laser output was collimated to about  $0.1 \text{ mm}^2$  along a light path of 10 mm in a quartz cell containing the solution under observation. To assure linear response of the photoconductor the power density behind the cell was attenuated. A mechanical shutter between laser and the cell initiated the illumination. Triethanolamine was used as the solvent for the methylene blue solution. The transmissions as measured with a Zeiss spectrophotometer ranged from 13.7 to 3%. When the shutter was opened at a high light level it was found that the signal increased from the initial level to a new steady value. The results of the experiments are theoretically analyzed and interpreted. D. P. F.

#### A65-31701 #

BEATS BETWEEN OSCILLATION MODES IN AN OPTICAL RUBY GENERATOR [BIENIIA MEZHDU TIPAMI KOLEBANII (MODAMI) V OPTICHESKOM RUBINOVOM GENERATORE].

V. V. Korobkin and A. M. Leontovich (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 49, July 1965, p. 10-15. 18 refs. In Russian.

Investigation of high-frequency modulation of radiation spikes from a ruby laser, using an ultrarapid photorecorder. A semi-confocal resonator with a 50-cm separation between the mirrors was employed in the laser. Discrimination of the angular modes was carried out by means of a special diaphragm inside the resonator. It is shown that with an increase in the diaphragm diameter modes of high transverse order are excited. It is concluded that high-frequency modulation of the intensity of the spikes is due to beats between the various modes. Distortion of the ruby crystal by inhomogeneities arising as a result of heating of the crystal by pumping light is found to have a considerable effect on the beat frequency.

(Author) A. B. K.

#### A65-31703 #

CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT ROOM TEMPERATURE ON  $\text{CaWO}_4$  WITH  $\text{Nd}^{3+}$  [NEPRERYVNYI OPTICHESKII KVANTOVYI GENERATOR NA  $\text{CaWO}_4$  S  $\text{Nd}^{3+}$ , RABOTAUSHCHII PRI KOMNATNOI TEMPERATURE].

A. A. Kaminskii, L. S. Kornienko, G. V. Maksimova, V. V. Osiko, A. M. Prokhorov, and G. P. Shipulo (Moskovskii Gosudarstvennyi Universitet, Institut Iadernoi Fiziki; Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 49, July 1965, p. 31-35. 11 refs. In Russian.

Description of the structure and main characteristics of a water-cooled optical quantum generator operating at room temperature on  $\text{CaWO}_4$  with  $\text{Nd}^{3+}$ . Problems connected with the maintenance of the required operating temperature are considered. (Author) A. B. K.

#### A65-31705 #

INVESTIGATION OF A SPARK DISCHARGE IN AIR PRODUCED BY FOCUSING THE RADIATION FROM A LASER. II [ISSLEDOVANIIE ISKRY V VOZDUKHE, VOZNIKAIUSHCHEI PRI FOKUSIROVANIIE IZLUCHENIIA LAZERA. II].

S. L. Mandel'shtam, P. P. Pashinin, A. M. Prokhorov, Iu. P. Raizer, and N. K. Sukhodrev (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 49, July 1965, p. 127-134. 19 refs. In Russian.

Results of an experimental investigation of the initial stage of a discharge in air induced by focusing the radiation from a laser. The plasma temperature  $T_e$  produced in the region of the focus is determined on the basis of the spectrum of recombination radiation in the soft X-ray range,  $\lambda \approx 10 \text{ \AA}$ , and is found to be equal to 50 to 60 eV. From a study of the laser radiation scattered on the plasma it is concluded that the ionization front moves toward the focusing lens. The velocity of the front is measured on the basis of the Doppler shift of the wavelength of the scattered light and is found to be equal to  $\approx 10^7 \text{ cm/sec}$ . A hydrodynamic mechanism of broadening of the ionization region is considered. The values for the velocity of the detonation wave front and the plasma temperature behind the front, estimated on the basis of this mechanism, are found to be in satisfactory agreement with those found experimentally.

(Author) A. B. K.

#### A65-31732

THERMAL CHARACTERISTICS OF  $\text{GaAs}$  LASER JUNCTIONS UNDER HIGH POWER PULSED CONDITIONS.

W. Engeler and M. Garfinkel (General Electric Co., Research Laboratory, Schenectady, N.Y.).

*Solid-State Electronics*, vol. 8, July 1965, p. 585-604. 16 refs.

Calculation of the temperature rise at the junction of a  $\text{GaAs}$  laser for a variety of pulse currents and base temperatures. The problem is first solved analytically by an approximation assuming constant thermal parameters, and then by a machine calculation taking into account the temperature variation of the thermal conductivity and the heat capacity. These solutions are compared and discussed in terms of practical laser design parameters. The effects of bulk resistivity and contact resistance are included.

(Author) M. M.

#### A65-31762

DISPERSION CHARACTERISTICS OF THE  $1.15\text{-}\mu$  He-Ne LASER LINE.

H. S. Boyne, M. M. Birky, and W. G. Schweitzer, Jr. (National Bureau of Standards, Atomic Physics Div., Washington, D.C.). *Applied Physics Letters*, vol. 7, Aug. 1, 1965, p. 62-65. 7 refs. NASA Contract No. 8-49296(G).

Experimental investigation of the complicating effects of a neighboring neon absorption transition on the predicted behavior of the frequency deviation  $\delta\nu$  resulting from a variation in the relative inversion density above threshold in the  $1.15\text{-}\mu$  He-Ne laser line. Dispersion curves were obtained by modulating the inversion density in three ways: (1) power modulation of the plasma discharge, (2) modulation of the  $2s_2$  level in neon by optically pumping the  $2^3S$  He level with the  $2^3S - 2^3P$   $1.083\text{-}\mu$  He line, (3) modulation of the  $2p_4$  level of neon by optically pumping it with the  $1s_4 - 2p_4$   $0.6096\text{-}\mu$  line and the  $1s_5 - 2p_4$   $0.5944$  line in neon. A block diagram of the experimental arrangement used for observing the frequency dispersion curves is given.

R. A. F.

#### A65-31763

LASER PULSE-SHAPING AND MODE-LOCKING WITH ACOUSTIC WAVES.

A. J. DeMaria and D. A. Stetser (United Aircraft Corp., Research Laboratories, East Hartford, Conn.).

*Applied Physics Letters*, vol. 7, Aug. 1, 1965, p. 71-73. 5 refs. Contract No. DA-28-043-AMC-00259(E).

Generation of square-, stepped-, and sawtooth-shaped laser output pulses from the propagation of combinations of traveling and stationary periodic refractive index perturbations within the optical feedback path of an argon ion laser. The pulse-shaping procedure is described and illustrated with oscillograph traces. The existence of an lf radio signal with frequency decreasing as the frequency of the perturbation approaches the axial-mode spacing frequency is thought to suggest that laser-acoustic interactions offer an obvious solution to the problem of obtaining a variable delay of an electrical signal.

R. A. F.

#### A65-31764

EFFECTS OF LASER RADIATION.

John F. Ready (Honeywell, Inc., Research Center, Electro-Optics Section, Hopkins, Minn.).

*Industrial Research*, vol. 7, Aug. 1965, p. 44-47, 49, 50.

Simplified discussion of the effects and applications of laser radiation. The characteristics of laser light are described. The basic difference between solid (ordinary) lasers and pulsed Q-switched lasers is explained. The influence of pulse shape and duration on the effects of laser radiation is described. Melting and vaporization of metals are discussed. Some applications, including laser welding and machining and such biological effects as retina welding, protein coagulation, and tumor irradiation, are described. The effects of laser radiation on transparent materials are described.

R. A. F.

#### A65-31773

MASTER EQUATION FOR THE STATISTICAL OPERATOR OF SOLID STATE LASER.

W. Weidlich and F. Haake (Stuttgart, Technische Hochschule, Institut für theoretische und angewandte Physik, Stuttgart, West Germany).

*Zeitschrift für Physik*, vol. 186, no. 3, 1965, p. 203-221. 11 refs.

Derivation of a master equation for the complete statistical operator of a laser model. The whole system containing atoms, field and several thermal reservoirs, the latter providing loss effects and pumping, is treated according to quantum mechanics. The master equation is at first solved in the self-consistent field approximation (SCFA). The results essentially confirm those given by quasi-classical theories, including the coherence properties of the light mode. Secondly, an approximate treatment is given of particle-field correlations which go beyond the SCFA and therefore beyond the quasi-classical approach. It is shown explicitly that such correlation effects influence the coherence behavior of the light-field, -i.e., a further small deviation from the pure Glauber state is obtained.

(Author) W. M. R.

**A65-31843 \*****KINETIC PROCESSES IN A GAS LASER.**

E. M. Belenov and A. N. Oraevskii.

*(Optika i Spektroskopiia*, vol. 18, May 1965, p. 858-865.)*Optics and Spectroscopy*, vol. 18, May 1965, p. 479-483. 34 refs.

Translation.

[For abstract see Accession no. A65-27738 17-16]

**A65-31844 \*****EXPERIMENTAL INVESTIGATION OF BEAM DIVERGENCE IN THE NEON-HELIUM LASER ( $\lambda = 0.63 \mu$ ).**

D. I. Mash, V. F. Papulovskii, and L. F. Chirina.

*(Optika i Spektroskopiia*, vol. 18, May 1965, p. 866-869.)*Optics and Spectroscopy*, vol. 18, May 1965, p. 483-485. Translation.

[For abstract see Accession no. A65-27739 17-16]

**A65-31878 \*****SOME OBSERVATIONS ON THE PROCESSES IN THE DECAYING PLASMA OF THE He-Ne PULSE DISCHARGE UNDER THE GENERATION CONDITIONS.**

V. S. Egorov and A. S. Tibilov.

*(Optika i Spektroskopiia*, vol. 18, Apr. 1965, p. 719-721.)*Optics and Spectroscopy*, vol. 18, Apr. 1965, p. 405, 406. 6 refs. Translation.

Investigation of plasma decay in the pulse discharge of an He-Ne laser, under conditions of generation. The results are given as a set of graphs showing the relationship of generation amplitude to discharge current and total mixture pressure and the relationship of generated-pulse delay time to discharge-current pulse amplitude and total mixture pressure. These results are discussed. R. A. F.

**A65-31879****ARMED FORCES COMMUNICATIONS AND ELECTRONICS ASSOCIATION, ANNUAL CONVENTION, 19TH, FORT MONMOUTH, N. J., JUNE 1965, PROCEEDINGS.***Signal*, vol. 19, Aug. 1965. 80 p.**CONTENTS:**

**LASER PRINCIPLES.** John W. Coltman (Westinghouse Electric Corp., Pittsburgh, Pa.), p. 43-46. [See A65-31880 20-16]

**CURRENT AND PROJECTED LASER STATE-OF-THE-ART.** J. L. Walsh (Institute for Defense Analyses, Arlington, Va.), p. 46-48. [See A65-31881 20-16]

**TERRESTRIAL APPLICATIONS.** Charles R. Kline (Westinghouse Electric Corp., Baltimore, Md.), p. 48-52. [See A65-31882 20-16]

**SPACE APPLICATIONS.** John M. Walker (NASA), p. 52-55. [See A65-31883 20-16]

**A65-31880****LASER PRINCIPLES.**

John W. Coltman (Westinghouse Electric Corp., Research Laboratories, Pittsburgh, Pa.).

(Armed Forces Communications and Electronics Association, Annual Convention, 19th, Fort Monmouth, N. J., June 1965, Paper.) *Signal*, vol. 19, Aug. 1965, p. 43-46.

Explanation of the basic principles governing laser operation, approached from the standpoint of the electronics engineer. The oscillating circuit of the laser - the cavity - is described. The electron is the agent for the conversion of current energy to a high-frequency oscillating field. The energy of the electron, rather than its motion, is important. The fluorescence process - the basic mechanism in the optically pumped laser - is described. It is necessary for the majority of electrons to be in the upper energy level, if a laser is to generate net coherent power. Population inversion is explained; the various types of laser are in a sense an expression of the variety of means which have been found to induce this necessary state. Various resonator configurations, pumping mechanisms, and active materials used in lasers are listed.

R. A. F.

**A65-31881****CURRENT AND PROJECTED LASER STATE-OF-THE-ART.**

J. L. Walsh (Institute for Defense Analyses, Arlington, Va.).

(Armed Forces Communications and Electronics Association, Annual Convention, 19th, Fort Monmouth, N. J., June 1965, Paper.) *Signal*, vol. 19, Aug. 1965, p. 46-48.

Description of the experimental configurations, performance features, and limitations of various kinds of lasers. The configuration of the He-Ne laser is explained, along with its operating frequency range, efficiency, and power output. Next considered are the ion lasers; a table gives the wavelength range, power output, and some other characteristics for several species. Optically pumped solid-state lasers are discussed, and Q-switching is explained; the differences between long- and short-pulse laser characteristics and operation are also considered. The semiconductor laser - which is pumped by a large current flow through a semiconducting junction and operates at efficiencies of up to 50% - is also described.

R. A. F.

**A65-31882****TERRESTRIAL APPLICATIONS.**

Charles R. Kline (Westinghouse Electric Corp., Defense and Space Center, Baltimore, Md.).

(Armed Forces Communications and Electronics Association, Annual Convention, 19th, Fort Monmouth, N. J., June 1965, Paper.) *Signal*, vol. 19, Aug. 1965, p. 48-52.

Brief survey of some laser uses in medicine, manufacturing, spectroscopy, nonlinear optics, communications, and optical radar. Spotwelding of detached retinas and irradiation of malignant tumors are considered. Small-area welding, particularly the welding of leads to semiconductors, is discussed, along with the drilling of small-diameter holes and interference measurements over long distances. The production of nonlinear optical effects and its implications are described. The uses of lasers in Raman spectroscopy are considered, and laser holography is outlined. The advantages of lasers in communication are discussed, and some of the possible modulation techniques are considered. The basic aspects of laser radar are discussed, and a hand-held tracking device is illustrated and described.

R. A. F.

**A65-31883****SPACE APPLICATIONS.**

John M. Walker (NASA, Office of Advanced Research and Technology, Communications and Tracking Branch).

(Armed Forces Communications and Electronics Association, Annual Convention, 19th, Fort Monmouth, N. J., June 1965, Paper.) *Signal*, vol. 19, Aug. 1965, p. 52-55.

Brief description of the NASA research program in electro-optics and the importance of this research to the use of lasers and other applications of optics in space. In NASA, there are two broad categories of applications for electro-optics - one including communications, tracking, navigation, and guidance, and the other consisting of astronomical observations from space. Broad research objectives based on these applications are given. A knife-edge test using a laser to assure that telescope mirrors are diffraction-limited is described and illustrated, and the "point-ahead" problem - properly compensating for the movement of the ground station during satellite-to-earth transmission - is discussed. Other research, such as the Gemini laser experiment and laser tracking of Explorer 22, is also described.

R. A. F.

**A65-31884 \*****THEORY OF LASER RADIATION IN INDIRECT BAND-TO-BAND TRANSITIONS [TEORIJA LAZERNOGO IZLUCHENIIA NA NEPRIAMYKH ZONA-ZONNYKH PEREKHODAKH].**

V. S. Mashkevich and V. L. Vinetskii (Akademiia Nauk Ukrainskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR).

*Fizika Tverdogo Tela*, vol. 7, July 1965, p. 1987-1993. 7 refs.

In Russian.

Calculation of several parameters for a special case of stationary-laser radiation. The quasi-Fermi level, frequency, threshold pumping value, and particular mode - i.e., mode in which production takes place - are determined in the case of a radiative intraband transition with the production of one optical phonon. In the most favorable case, the threshold is several  $\xi$  times less than that calculated for a laser in a direct band-to-band transitions, where  $\xi$  is the ratio of average losses for nonparticular modes to losses for the particular mode.

R. A. F.

A65-31942

**A65-31942**

SOME EXPERIMENTS RELATING THE INDUCTION OF ACOUSTIC WAVES IN SEVERAL MATERIAL MEDIA CROSSED BY OR SUBJECTED TO THE IMPACT OF LASER PULSES [QUELQUES EXPERIENCES RELATANT L'INDUCTION D'ONDES ACOUSTIQUES DANS DIVERS MILIEUX MATERIELS TRAVERSES PAR OU AYANT SUBI L'IMPACT D'IMPULSIONS LASER].

Marc Bruma and Michel Velghe (Centre National de la Recherche Scientifique, Laboratoire Laser, Bellevue, Seine-et-Oise, France). (Journées de Physique, Royat, Puy-de-Dôme, France, Sept. 16-18, 1964, Paper.)

Journal de Physique, vol. 26, June 1965, p. 341-344. 7 refs. In French.

Description of experiments showing that evaporated CdS thin films may be processed to act as piezoelectric transducers for detecting laser-induced elastic vibrations. Taking advantage of the high piezoelectric sensitivity and fast response of CdS thin films, it was possible to detect the acoustic vibrations transferred in air by an unfocused non-Q-switched ruby laser beam, of 1/3-joule total energy output. The waveforms of the elastic vibrations detected by the CdS transducer are correlated to the laser pulse spikings on a double-beam oscilloscope with the response of a conventional silicon photodiode (SD 100 from Edgerton, Germeshausen, and Grier) as reference. In this experiment, the CdS thin-film transducer was not illuminated by the laser beam and the propagation of the beam was not perturbed or affected by the presence of the detecting device because the energy for detection was transferred via the elastic vibration in air along the path of the laser beam. (Author) M. F.

**A65-32128 #**

CONDUCTION COOLING OF A TRAVELING WAVE MASER SUPERCONDUCTING MAGNET IN A CLOSED-CYCLE REFRIGERATOR.

J. P. McEvoy, Jr., L. C. Morris, and J. F. Panas (Radio Corporation of America, Camden, N.J.).

IN: ADVANCES IN CRYOGENIC ENGINEERING. VOLUME 10, SECTIONS A-L. PROCEEDINGS OF THE CRYOGENIC ENGINEERING CONFERENCE, UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA., AUGUST 18-21, 1964. [A65-32083 20-27] NSF-supported conference.

Edited by K. D. Timmerhaus.

New York, Plenum Press, 1965, p. 487-492. 5 refs.

Description of the successful operation of an iron-core superconducting magnet in a closed-cycle refrigerator. The magnet, which provides the magnetic field for a tunable S-band traveling-wave maser (TWM), weighs only 6 lb and occupies  $\sim 30 \text{ in}^3$ . It is believed to be the first time a useful superconducting magnet has been cooled in a closed-cycle refrigerator by thermal conduction rather than immersion in a liquid-helium bath. The magnet can be used with any type of closed-cycle refrigerator which produces a cold flange at 4.2°K and is operative in any orientation. The approach may advance the realization of reliable TWM amplifiers in practical microwave receiver systems such as satellite communications, radiometry, and radar. B. B.

**A65-32209**

COMPARISON OF OBSERVED AND PREDICTED STIMULATED RAMAN SCATTERING CONVERSION EFFICIENCIES.

D. Weiner, S. E. Schwarz, and F. J. McClung (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

Journal of Applied Physics, vol. 36, Aug. 1965, p. 2395-2399. 11 refs.

Contract No. AF 33(657)-11650.

Measurement of the absolute Raman scattering cross section for the  $1345\text{-cm}^{-1}$  shifted Stokes line in nitrobenzene using a ruby laser. The efficiency of conversion of radiation from a giant pulse ruby laser into stimulated Raman scattered radiation for this line was also measured. It was found that the average intensity needed to produce a given conversion is one or two orders of magnitude less than that predicted by the theory of Hellwarth using the measured cross section. Some possible explanations for this disagreement are discussed. (Author) M. F.

**A65-32219**

SATURATION EFFECTS IN HIGH-GAIN LASERS.

W. W. Rigrod (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

Journal of Applied Physics, vol. 36, Aug. 1965, p. 2487-2490. 5 refs.

Generalization of earlier calculations of the radiation intensity obtainable from lasers with homogeneous line broadening to include arbitrarily large loss fractions per pass. The conditions for maximum transmitted or internally dissipated power are derived, as well as the axial distribution of radiation within the active medium. The relevance of these calculations to high-gain gas lasers is discussed. (Author) M. F.

**A65-32228**

ROLE OF FLARE IMAGES IN THE SELF-DESTRUCTION OF A LENS IN A STRONG LASER BEAM.

G. L. Rogers (Birmingham College of Advanced Technology, Birmingham, England).

Journal of Applied Physics, vol. 36, Aug. 1965, p. 2598.

Study of a recent experiment with a small Q-switched laser showing that damage can readily occur to a microscope or other objective used to concentrate the beam onto a small area of metal. A study of the nature of the damage shows clearly that the formation of flare images within the material of the objective plays a substantial part. It is clear that certain types of objective are a bad risk, and the choice of suitable types is recommended to avoid damage and disappointment. In particular, a number of traditional microscope objectives end with a roughly hemispherical component. A photomicrograph show of a damaged region resulting from flare focus is given. The finely recrystallized surface of the initial bubble is clearly seen, and the upper parts of the crater can be discerned, though they are beyond the focal depth of the objective. Flare effects can be further reduced by a bloomed surface calculated for  $6943 \text{ Å}$ , or the wavelength in use. A standard bloomed surface calculated around  $5500 \text{ Å}$  is already losing efficiency at  $6943 \text{ Å}$ . M. F.

**A65-32229**

GAS EFFECTS PRODUCED BY A PULSED LASER BEAM IN A BALLISTIC TORSIONAL PENDULUM.

M. Stimler and Z. I. Slawsky (Maryland, University, Dept. of Physics and Astronomy, College Park; U.S. Naval Ordnance Laboratory, Silver Spring, Md.).

Journal of Applied Physics, vol. 36, Aug. 1965, p. 2598, 2599.

Observed pendulum response in a torsion pendulum photometer with a sensitivity of  $1.00 \times 10^{-2} \text{ dyne-cm/rad}$ . Changes in peak deflection of the pendulum were used to measure the energy in a pulsed laser beam by reflection from a pair of vanes. When operated at pressures below  $5 \times 10^{-5} \text{ torr}$  the deflection changes were due mainly to photon momentum and were independent of both gas pressure and initial direction of rotation. As the pressure was increased, an unusual pressure dependence was observed with change in pressure, the response of the pendulum suspension to the pulse was opposite to what would be expected from radiometer effects. In addition, the deflection depended on the initial direction of rotation of the pendulum. A graph of the deflection change vs pressure is included. The laser energy was maintained constant, and each point represents an average deflection change for several laser actuations at each pressure. Another figure is a plot showing the effect of a series of seven laser pulses on the pendulum oscillation when the pressure was  $4 \times 10^{-4} \text{ torr}$ . The observed pendulum response is not due to conventional radiometer effects because (1) the force is toward the laser and (2) the results are asymmetric, depending on the initial rotation direction. M. F.

**A65-32353 #**

INFLUENCE OF FOG ON THE RANGE OF GROUND COMMUNICATION USING AN OPTICAL CARRIER.

S. P. Erkovich, Iu. V. Pisarevskii, F. S. Ageshin, and G. A. Tregubov.

(Elektrosvyaz', vol. 18, Dec. 1964, p. 16-21.)

Telecommunications and Radio Engineering. Telecommunications, vol. 18, Dec. 1964, p. 12-16. 6 refs. Translation.

[For abstract see Accession no. A65-15349 06-07]

**A65-32585 #**

IMAGE TUBE STREAK CAMERA.

R. N. Burbeck and P. Brooke (Associated Electrical Industries, Ltd., Rugby, War., England).

Journal of Scientific Instruments, vol. 42, Aug. 1965, p. 535, 536.

Description of an image converter camera said to be capable of higher writing speeds and more convenient to use than existing mechanical cameras, and which also gives an increase in sensitivity. A slit image of the event is focused onto the photocathode of the image converter tube. The resulting electron beam is accelerated and focused onto a fluorescent screen, across which it can be deflected at high speed by means of the sweep deflector plates. The image from the fluorescent screen can be recorded, either on Polaroid or normal film. The shutter aperture and its associated deflector plates are used to gate the beam off at the end of the scan, while the remaining deflector plate can conveniently be used for time calibration. A photograph shows an enlarged record obtained from a 100 nsec Q-switched laser pulse. The minimum resolving time of the camera is in the region of 0.1 nsec. M.M.

#### A65-32586 #

##### THE BARR AND STROUD LASER RANGEFINDER.

J. R. Davy (Barr and Stroud, Ltd., Glasgow, Scotland).  
Journal of Scientific Instruments, vol. 42, Aug. 1965, p. 536, 537.

Description of a laser ranging device capable of providing fast accurate ranges of noncooperative targets without the inherent difficulties of radar and optical rangefinders. The laser rangefinder operates on the radar principle, but - since this is essentially a single shot device - the electronic techniques are slightly different from conventional radar devices. A simplified block diagram of the equipment is shown. The laser rangefinder is divided into a head unit and a power unit. The head unit is a triaxial system containing the transmitter, sight, and receiver. The power unit contains the condenser bank, which has a maximum energy storage of 200 joules, and the pulse-forming network. The whole system operates from nickel-cadmium batteries which are rechargeable. The rangefinder is capable of ranging to the limit of visibility up to 6 km, and in better visibility conditions the maximum range is extended to 10 km. The accuracy is to 10 m, irrespective of range, and there is a minimum range of 300 m determined by atmospheric backscatter. M.M.

#### A65-32588 #

##### A GALLIUM ARSENIDE LASER RANGEFINDER USED AS AN AIRCRAFT ALTIMETER.

F. E. Birbeck and K. G. Hambleton (Services Electronics Research Laboratory, Baldock, Herts., England).  
Journal of Scientific Instruments, vol. 42, Aug. 1965, p. 541, 542.

Description of an optical laser rangefinder used to eliminate the spurious echoes which are troublesome to aircraft radio altimeters over particular types of terrain. The laser system can only operate in good visibility and cannot be relied on as an altimeter in itself. However, it can be used to check or calibrate existing types of altimeters under actual flying conditions over various types of terrain. Experimental flights with the equipment indicate that heights of up to 1000 ft can be measured with an accuracy to about 5 ft over a wide variety of terrain. Measurements of the amplitude of the received pulses have enabled values for the scattering coefficients of the various types of ground to be deduced. One result of particular interest is that double echoes are often obtained over wooded ground due to simultaneous reflection from the tops of the trees and the ground beneath. This enables the height of the trees to be measured as well as the height of the aircraft and is one example of the way in which a laser altimeter can emphasize features of the terrain which may not be resolved or detected by a radio altimeter. M.M.

#### A65-32621 #

##### THE THEORY AND APPLICATION OF MASERS AND LASERS.

Charles H. Townes (Massachusetts Institute of Technology, Cambridge, Mass.).

IN: SELECTIONS FROM THE TRW SPACE TECHNOLOGY LABORATORIES; LECTURE SERIES. VOLUME 2.

Edited by T. L. Branigan.

Redondo Beach, Calif., Space Technology Laboratories, Inc., 1965, p. 4-13.

General review of the present status of maser and laser technology and a discussion of present and future applications. The principles of atomic or molecular energy levels, ground and metastable states, stimulated emission, and coherent light oscillation are described as explaining the fundamentals of maser and laser

action. The performance of Cs-He maser systems, He-Ne masers, and ruby lasers is described. Bandwidths obtainable, radiation intensity, and power output for masers and lasers are analyzed. Applications to the field of communications, exploration of the lunar surface, new welding techniques, and surgical cauterization are discussed. D. P. F.

#### A65-32697 #

##### ACHIEVEMENTS AND POTENTIALITIES OF LASER TECHNIQUES.

S. A. Ziul'ko.

(Radiotekhnika, vol. 19, Oct. 1964, p. 3-8.)

Telecommunications and Radio Engineering. Radio Engineering,

vol. 19, Oct. 1964, p. 67-70. 5 refs. Translation.

#### A65-32707

##### QUANTUM STATISTICAL DYNAMICS OF LASER AMPLIFIERS.

A. E. Glassgold (New York University, New York, N.Y.) and Dennis Holliday (RAND Corp., Santa Monica, Calif.).

Physical Review, 2nd Series, Section A, vol. 139, Sept. 13, 1965, p. A1717-A1734. 18 refs.

USAF-Army-sponsored research.

Development of a quantum statistical procedure for studying interacting radiation fields and application of the procedure to a model laser operating as a linear amplifier. The method utilizes an expansion of the density matrix in terms of a complete set of orthogonal operators originally used by Weyl. One mode of the laser field is considered to interact with a pumping mechanism and with a loss mechanism. A general solution for the density matrix is obtained and then applied to various initial conditions. It is found that a classical statistical interpretation of the results is frequently appropriate. (Author) M. F.

#### A65-32743

##### INVESTIGATION OF THE OPERATING CHARACTERISTICS OF THE 3.5 $\mu$ XENON LASER.

Peter O. Clark (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

IEEE Journal of Quantum Electronics, vol. QE-1, June 1965, p. 109-113. 11 refs.

Contract No. JPL-950803.

Measurement of the amplification at 3.508  $\mu$  in pure xenon dc-excited discharges over a wide range of gas pressures and for several discharge diameters. For pressures greater than 10 torr, the unsaturated gain increases monotonically as the pressure decreases. Gain varies inversely as the radius for large bore (radius  $\geq 3.5$  mm) amplifiers, but a complicated, pressure-dependent variation between gain and discharge diameter was observed in amplifiers of less than 3-mm diameter. Gain saturation occurs at low signal levels and results in small output powers from conventional xenon lasers. (Author) M. F.

#### A65-32745

##### STIMULATED BRILLOUIN SCATTERING AS A PARAMETRIC INTERACTION.

D. A. Sealer and H. Hsu (Ohio State University, Dept. of Electrical Engineering, Antenna Laboratory, Columbus, Ohio).

(Electron Device Research, Annual Conference, 22nd, Cornell University, Ithaca, N.Y., June 24-26, 1964, Paper.)

IEEE Journal of Quantum Electronics, vol. QE-1, June 1965, p. 116-124. 9 refs.

Contract No. AF 33(657)-10824.

Production of a forward-traveling coherent acoustic wave and of a backward-traveling electromagnetic wave in the stimulated Brillouin scattering of an intense laser beam. This interaction is studied from the coupled mode approach and shown to be describable as a parametric interaction. An inherent instability of this particular interaction is discussed. Frequencies of the interacting waves are calculated for quartz and cadmium sulfide. The nonlinearity is shown to be due to the electrostrictive and photoelastic properties of the medium. By expressing the coupling coefficient as a tensor of rank four, selection rules for the interaction in isotropic and certain anisotropic media are derived. Finally the experimental approach for detection of the acoustic wave is discussed. (Author) M. F.

**A65-32746****MICROWAVE MODULATION OF A RUBY LASER OUTPUT BY ABSORPTION.**

Di Chen (Honeywell, Inc., Research Center, Hopkins, Minn.).  
IEEE Journal of Quantum Electronics, vol. QE-1, June 1965,  
 p. 125-131. 9 refs.

Consideration of the exhibition of the Zeeman effect by ruby in the energy levels responsible for the absorption of the  $R_1$  line. When a ruby laser is directed to pass through a section of unexcited ruby rod, the intensity of the transmitted beam is strongly dependent on the magnetic field applied to the absorber. This effect was used to modulate the amplitude of a pulsed ruby laser in the microwave frequency region. The experimental modulator consisted of a 0.2-in.-long ruby absorber located at one end of an S-band  $TE_{111}$ -mode cylindrical cavity pumped by a 3.2-Gc microwave source. A dc bias magnetic field was also applied to the absorber. When both the laser and the absorber rods were cooled to 80°K, the modulated beam attained maximum modulation index with a bias field of 2.5 koeerst. This and other experimental results agree well with calculations made from theoretical analysis of this modulation technique and indicate that the various known relaxation mechanisms in the spin system of ruby do not impose a frequency limit to this method of modulation.

(Author) M. F.

**A65-32747****LASER ACTION IN THE IONIC SPECTRA OF ZINC AND CADMIUM.**

G. R. Fowles and W. T. Silfvast (Utah, University, Dept. of Physics, Salt Lake City, Utah).

IEEE Journal of Quantum Electronics, vol. QE-1, June 1965,  
 p. 131.

NSF-supported research.

Letter on laser oscillation in the visible spectra of singly ionized zinc and cadmium obtained with pulsed discharges in the heated vapors of these metals mixed with noble gases. The optical resonator was a near-confocal configuration of highly reflecting dielectric mirrors. The quartz plasma tube (5-mm bore and 150-cm length) was fitted with Brewster windows and internal electrodes at each end. The presence of the carrier gas, 1 to 2 torr of helium or neon, prevented the metal vapor from fouling the Brewster windows during operation. The cold cathode discharge was excited by means of a pulse modulator having a maximum output of 15 kv at 12.5 amp with a pulse duration of 1.5  $\mu$ sec at a rate of 800 pulses/sec. The lasing wavelengths of zinc were 7757 and 4925 Å, and those of cadmium were 5337 and 5378 Å. The operating range of oven temperature for zinc was about 300 to 400°C, whereas the range for cadmium was approximately 200 to 320°C. These temperatures correspond roughly to vapor pressures of  $10^{-3}$  to  $10^{-1}$  torr in both metals. Oscillation occurred only with helium as the carrier gas in the case of zinc, but cadmium underwent laser action with either helium or neon, higher output being obtained with helium. The fact that the  $5/2 \rightarrow 3/2$  member of the  $2F \rightarrow 2D$  transition undergoes laser action in cadmium, but not in zinc or mercury, may indicate that a relatively high population inversion is attained in this experiment.

(Author) M. F.

**A65-32748****SIMULTANEOUS LASER OSCILLATION AT  $R_1$  AND  $R_2$  WAVELENGTHS IN RUBY.**

J. A. Calviello, E. W. Fisher, and Z. H. Heller (Cutler-Hammer, Inc., Airborne Instruments Laboratory Div., Melville, N. Y.).  
IEEE Journal of Quantum Electronics, vol. QE-1, June 1965,  
 p. 132.

Observation of simultaneous laser oscillation at both  $R_1$  and  $R_2$  wavelengths in normal and Q-spoiled operation. Laser oscillation at the  $R_1$  and  $R_2$  wavelengths occurs in spiking. These spikes are similar to those observed when operating at the  $R_1$  wavelength only. Usually  $R_1$  and  $R_2$  spikes occur alternately, but occasionally they occur simultaneously. When the laser was operated Q-spoiled, the  $R_1$  and  $R_2$  giant pulses always occurred simultaneously, within the rise time of the detector, 10 nsec. The simultaneous generation of the coherent  $R_1$  and  $R_2$  high power signals reported here is of interest for optical mixing experiments.

(Author) M. F.

**A65-32749****LASER BIBLIOGRAPHY.**

K. Tomiyasu (General Electric Co., Schenectady, N. Y.).  
IEEE Journal of Quantum Electronics, vol. QE-1, June 1965,  
 p. 133-156.

Bibliography of articles compiled during the period from June to Dec. 1964. The subject categories listed include: laser analyses, ruby laser, neodymium laser, He-Ne gas laser, organic laser, GaAs injection luminescent devices, laser amplifiers, giant pulse techniques (Q-switching), laser-beam control and steering, coherence, interference and quantum noise, pumping and light sources, transmission, propagation scattering, reflection and filtering, nonlinear, thermal, and other interaction effects with matter, and laser instrumentation.

M. F.

**A65-32773 =****ELECTRON PARAMAGNETIC RESONANCE (EPR) [ELEKTRO-NOWY REZONANS PARAMAGNETYCZNY - ERP].**

J. Stankowski (Polska Akademia Nauk, Instytut Fizyki, Zakład Dielektryków Poznań, Poland).

Postępy Fizyki, vol. 16, no. 3, 1965, p. 325-347. 22 refs. In Polish.

Discussion of the nature of EPR and its use in various areas of research. The Zeeman effect underlying the phenomenon of EPR is described, and the Lande splitting factor and other parameters in the EPR spectrum are examined. Ingram's double-modulation spectrometer for detecting EPR signals is described. The Overhauser effect which uses EPR and NPR in combination to polarize atomic nuclei is examined; showing the use of this effect made it possible to increase the resolving power of the Ingram spectrometer. The use of EPR by a solid-state maser is explained.

V. P.

**A65-32798****LASER WELDING.**

K. J. Miller and J. D. Ninnikhoven (Garrett Corp., AiResearch Manufacturing Co., Metals Joining Laboratory, Los Angeles, Calif.).  
Machine Design, vol. 37, Aug. 5, 1965, p. 120-125.

Description of the process of pulsed laser welding and some of its applications. The laser welding technique allows excellent control of heat input and can fuse metal adjacent to a glass or ceramic seal without damaging the latter. A major limitation is shallow penetration, on the order of 0.020 in. The average duration of a laser pulse for welding is 0.002 sec, and pulse frequency is about 10 p/sec. The workpiece may be either rotated or moved fast enough so that the entire joint is welded with a single burst of light or many pulses are used to cover the joint. In the latter case, the weld line is composed of round solidified puddles, each overlapping the other by about half a puddle diameter. The laser beam is collimated to a thickness of less than 100  $\mu$  in diameter, so the welding fixtures must track within this range of accuracy. The process is extremely stringent in regard to freedom from oxides or inclusions of foreign matter.

D. P. F.

**A65-32844****MODE COMPETITION AND COLLISION EFFECTS IN GASEOUS OPTICAL MASERS.**

R. L. Fork and M. A. Pollack (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).

Physical Review, 2nd Series, Section A, vol. 139, Aug. 30, 1965,  
 p. A 1408-A 1414. 12 refs.

Study of a gas laser under the condition of oscillation on two linearly polarized modes. A modified form of Lamb's theory which includes collision effects is given. Experimental and theoretical curves of the mode intensities and beat frequencies are compared. It is concluded that the modified theory is in good agreement with experimental results and that the collision-induced asymmetry in the optical-field-atom interaction curve significantly influences laser behavior.

R. A. F.

**A65-32874****TRANSVERSE ELECTRON-BEAM WAVE EXCITATION BY PHOTO-ELECTRIC MIXING OF LASER BEAMS.**

J. C. Bass (Sheffield, University, Dept. of Electrical Engineering, Sheffield, England).

Electronics Letters, vol. 1, Apr. 1965, p. 38, 39.

Theoretical demonstration that, by photoelectric mixing of laser beams which are incident obliquely onto a photosurface, transverse electron-beam waves may be excited. It should thus

be possible to construct transverse-field microwave phototubes for detecting AM laser signals. (Author) M. F.

#### A65-32952

##### THEORY OF LASER EMISSION VIA BAND-TO-BAND TRANSITIONS IN IMPURITY SEMICONDUCTORS.

G. Iu. Buriakovskii, V. L. Vinetskii, and V. S. Mashkevich (Akademii Nauk Ukrainskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR). (*Fizika Tverdogo Tela*, vol. 7, Apr. 1965, p. 1028-1036.) *Soviet Physics - Solid State*, vol. 7, Oct. 1965, p. 827-833. 5 refs. Translation.

[For abstract see Accession no. A65-26694 16-16]

#### A65-33006

##### MODULATION OF A HELIUM-NEON LASER BY THE LIGHT OF A HELIUM DISCHARGE [MODULATION D'UN LASER A HELIUM-NEON PAR LA LUMIERE D'UNE DECHARGE DANS L'HELIUM].

J. F. Delpech (Paris, Université, Institut d'Electronique, Centre d'Orsay, Orsay, Seine-et-Oise, France). *Electronics Letters*, vol. 1, Aug. 1965, p. 168, 169. In French.

Method of modulating laser intensity by optical action on the population mechanism of the upper level. Experiments have been made with a helium-neon laser using the  $3s_2-3p_4$  transition of neon (3.39- $\mu$  line). (Author) M. F.

#### A65-33047

##### AMPLIFICATION BY REFLECTION FROM AN ACTIVE INTERFEROMETER.

Vern N. Smiley, David K. Forbes, and Adolph L. Lewis (U.S. Navy, Electronics Laboratory, San Diego, Calif.).

*Applied Physics Letters*, vol. 7, July 1, 1965, p. 1, 2. 10 refs.

Discussion of amplification of a laser beam by reflection from a 0.93-m scanning gas-laser active interferometer at a wavelength of 2.03  $\mu$ . Reflectance-gain factors as high as 500 (370 net gain) were realized when operating just below oscillation threshold. Bandwidths measured less than 0.5 Mc, a factor of 20 smaller than that for the nonamplifying interferometer. Gain and band narrowing for two resonances of the 0.93-m scanning interferometer operating below oscillation threshold at a wavelength of 2.03  $\mu$  in He-Xe are verified photographically. B.B.

#### A65-33049

##### SATURATION OF THE MOLECULAR NITROGEN SECOND POSITIVE LASER TRANSITION.

Donald A. Leonard (Avco Corp., Avco-Everett Research Laboratory, Everett, Mass.).

*Applied Physics Letters*, vol. 7, July 1, 1965, p. 4-6.

Contract No. AF 04(694)-414.

Outline of experiments showing that while the output from a near confocal laser cavity with 30 cm of active length is 10 watts, the spontaneous emission from the same transition as observed from the side of the discharge tube is many kilowatts. By sending the output beam from an oscillator of this type through a synchronized open-ended amplifying section of relatively short length consisting of a similar discharge tube, it has been possible to drive this high gain transition into saturation and obtain output powers approaching the spontaneous emission power level. B.B.

#### A65-33050

##### PULSED-MOLECULAR-NITROGEN LASER THEORY.

Edward T. Gerry (Avco Corp., Avco-Everett Research Laboratory, Everett, Mass.).

*Applied Physics Letters*, vol. 7, July 1, 1965, p. 6-8. 6 refs.

Study of the formulation of a simple theory which appears to account for most of the observed features of the pulsed-molecular-nitrogen second-positive laser. An indirect excitation process was used by Bennett to explain the excitation of the second-positive nitrogen laser; while this type of indirect process may contribute to excitation of the second-positive band, the experimental data appear to be fitted quite well with the consideration of direct excitation only. The theory should be applicable to most short-pulse gas lasers where heavy-particle diffusion effects are not important. B.B.

#### A65-33055

##### CW HIGH POWER $N_2-CO_2$ LASER.

C. K. N. Patel (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

*Applied Physics Letters*, vol. 7, July 1, 1965, p. 15-17. 7 refs.

Account of the CW high-power operation of a  $N_2-CO_2$  laser oscillating on the P-branch rotational transitions of the  $0001-10^00$  vibrational band of  $CO_2$ . This is the first gas laser capable of producing high CW power output in the 10- $\mu$  IR region. By scaling up the cross section and the length of discharge, the  $N_2-CO_2$  laser holds the promise of producing much higher coherent CW power; this may be applicable to spectroscopy. B.B.

#### A65-33057

##### EFFICIENT DIFFRACTION OF LIGHT FROM ACOUSTIC WAVES IN WATER.

W. Kleinhans and D. L. Fried (North American Aviation, Inc., Space and Information Systems Div., Electro-Optical Laboratory, Torrance, Calif.).

*Applied Physics Letters*, vol. 7, July 1, 1965, p. 19-21.

Account of the successful diffraction of virtually all of an incident laser beam into a first-order mode by using traveling ultrasonic waves in water with the light incident at the Bragg angle associated with the acoustic wavelength. The ultrasonic cell was operated at 15 Mc. Experimental results are tabulated along with predictions of a theory based on the coupled-mode equations of Raman and Nath. The arrangement of the acoustic cell is shown schematically. B.B.

#### A65-33058

##### EFFECT OF FOREIGN GASES ON THE $CO_2$ LASER - R-BRANCH TRANSITIONS.

John A. Howe (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

*Applied Physics Letters*, vol. 7, July 1, 1965, p. 21, 22. 6 refs.

Examination of flowing mixtures of  $CO_2$  with various other gases relative to their effect on  $CO_2$  lasers, and discussion of the results and their implications concerning the inversion mechanism. It has been found that suitable mixtures also produce laser action on various transitions of the R branch. Measurements of relative power output on the line for various added gases are tabulated. There is a wide variation of output power with the gas added; furthermore, this variation is not likely to be solely the result of changes in near-resonant vibrational energy transfer, for the effect of added  $N_2$  is quite different from that of  $N_2O$ , although both are in near resonance. B.B.

#### A65-33308

##### LASER PHENOMENA IN EUROPIUM CHELATES. III - SPECTROSCOPIC EFFECTS OF CHEMICAL COMPOSITION AND MOLECULAR STRUCTURE.

C. Brecher, H. Samelson, and A. Lempicki (General Telephone and Electronics Laboratories, Inc., Bayside, N.Y.).

*Journal of Chemical Physics*, vol. 42, Feb. 1, 1965, p. 1081-1096.

20 refs.

Contract No. Nonr-4134(00).

Study of the emission spectra of the tris and tetrakis forms of four  $\beta$ -diketone chelates of europium in the solid powder, and in alcohol solution with and without dimethylformamide added. Partial dissociation of the tetrakis form was observed in solution. Effective site symmetries, subject to steric distortion, were derived for the tetrakis-chelated europium ion in the various hosts:  $D_{2d}$  in pure alcohol,  $C_{4v}$  in alcohol plus dimethylformamide, and  $C_{4v}$  in the crystal. For the tris chelates, in both their hydrated and anhydrous forms, a number of different low-symmetry species were found to exist simultaneously in each host medium. The implications of these findings to the laser capabilities of the chelates are discussed. (Author) M. F.

#### A65-33352

##### SPECTRAL CHARACTERISTICS OF A GAS LASER WITH TRAVELING WAVE.



## A65-33354

S. N. Bagaev, V. S. Kuznetsov, Iu. V. Troitskii, and B. I. Troshin (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Institut Fiziki Poluprovodnikov, Novosibirsk, USSR).

(ZHETF Pis'ma v Redaktsiiu, vol. 1, May 15, 1965, p. 21-24.)

JETP Letters, vol. 1, May 15, 1965, p. 114-116. Translation.

[For abstract see Accession no. A65-31306 20-16]

## A65-33354

GENERATION IN GaAs UNDER TWO-PHOTON OPTICAL EXCITATION OF NEODYMIUM-GLASS LASER EMISSION.

N. G. Basov, A. Z. Grasiuk, I. G. Zubarev, and V. A. Katulin (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(ZHETF Pis'ma v Redaktsiiu, vol. 1, May 15, 1965, p. 29-33.)

JETP Letters, vol. 1, May 15, 1965, p. 118-120. Translation.

[For abstract see Accession no. A65-31307 20-16]

## A65-33372

TIME-RESOLVED SPECTRAL OUTPUT OF PULSED GaAs LASERS.

T. Gonda, H. Junker, and M. F. Lamorte (Radio Corporation of America, Electronic Components and Devices Div., Somerville, N.J.).

(Institute of Electrical and Electronics Engineers, Electron Devices Meeting, Washington, D.C., Oct. 29, 30, 1964, Paper.)

IEEE Journal of Quantum Electronics, vol. QE-1, July 1965, p. 159-163.

Contract No. NAS 8-11612.

Data concerning the time-resolved spectra for pulse-operated gallium arsenide laser diodes. At high peak current values, joule heating results and the time-resolved laser spectra are seen to shift to longer wavelengths. A line-shift coefficient is defined for which the units are  $\text{\AA}/\text{amp}^2\text{-}\mu\text{sec}$ . For high peak current and long pulse length, the laser lines may shift 100  $\text{\AA}$  or more.

(Author) W. M. R.

## A65-33373

A "C"-BAND RUTILE TRAVELING-WAVE MASER.

L. C. Morris and D. J. Miller (Radio Corporation of America, Applied Research Section, Camden, N.J.).

IEEE Journal of Quantum Electronics, vol. QE-1, July 1965, p. 164-169. 11 refs.

Description of the development of a traveling-wave maser (TWM) with an iron-doped rutile active crystal and a meander line slow-wave circuit. The maser exhibited high-quality performance over a frequency range of 5.4 to 5.9 Gc. Iron-doped rutile exhibited a fast recovery time from saturation signals (3.5 msec). Inversion ratios of 10 to 1 were obtained with conventional microwave pumping techniques and a two-pump technique provided ratios of 13 to 1. This maser has been operated with a superconducting magnet.

(Author) W. M. R.

## A65-33374

THEORY OF OPTICAL MASER AMPLIFIERS.

F. T. Arecchi (Centro Informazioni Studi Esperienze; Milano, Università, Istituto di Fisica, Milan, Italy) and R. Bonifacio (Milano, Università, Istituto Fisica, Milan, Italy).

IEEE Journal of Quantum Electronics, vol. QE-1, July 1965, p. 169-178. 12 refs.

Research supported by the Italian National Research Council.

Description of the interaction between an electromagnetic (em) pulse and a maser medium by a general set of five equations, under the assumption of a homogeneously broadened electric-dipole transition with two Bloch relaxation times  $T_2$  and  $T_1$ , and of a linear broad-band loss mechanism. When the equations are specialized at resonance, their solutions include the results of the previous treatments on the amplifier problem obtained under particular assumptions. The steady-state pulse (SSP) introduced by Wittke and Warter for  $T_2/T_1 = 0$  is generalized for  $T_2/T_1 \neq 0$  and it is shown to propagate at the same velocity of the light in the medium. In the case  $T_2/T_1 = 0$  the steady state is described by exact analytical relations. For times short in comparison to the relaxation times, a solution is given which generalizes the usual interaction formula between an em field and a two-level system by introducing propagation

effects. In the general case out of resonance, it is shown that an SSP exists, and that its frequency coincides with the frequency of the atomic transition, independent of the frequency of the input field.

(Author) W. M. R.

## A65-33375

AMPLITUDE NOISE IN LASER OSCILLATORS.

H. A. Haus (Massachusetts Institute of Technology, Dept. of Electrical Engineering and Research Laboratory of Electronics, Cambridge, Mass.).

IEEE Journal of Quantum Electronics, vol. QE-1, July 1965, p. 179, 180. 15 refs.

Contract No. DA-36-039-AMC-03200(E).

Analysis of the amplitude noise in a maser oscillator, using a van der Pol equivalent circuit. The analysis is carried out both above and below threshold. The above-threshold analysis agrees qualitatively, but not quantitatively, with a linear analysis above threshold carried out by Gordon in 1964.

R. A. F.

## A65-33377

FM LASER COMMUNICATIONS THROUGH A HIGHLY TURBULENT ATMOSPHERE.

W. M. Doyle, W. D. Gerber, P. M. Sutton, and M. B. White (Philco Corp., Aeronutronic Div., Newport Beach, Calif.).

IEEE Journal of Quantum Electronics, vol. QE-1, July 1965, p. 181, 182.

Experimental investigation of the effects of atmospheric turbulence on the operation of a dual-polarization FM laser communication system. The system uses an intracavity birefringent modulator to obtain two collinear output beams having mutually perpendicular polarizations and a controllable frequency separation. Heterodyne detection and rf limiting and discrimination are thus possible without an optical local oscillator. Field tests were conducted over a half-mile of hot pavement and open ground. Laboratory tests were carried out with a 3-ft long hot plate and a hot-air blower. Results indicate that, due to the dual-frequency nature of the transmitted signal, the phase modulation brought about by the atmospheric turbulence results in nearly pure amplitude noise, against which the circuitry of the FM receiver effectively discriminates.

R. A. F.

## A65-33379

LASER ACTION IN IONIZED SULFUR AND PHOSPHORUS.

G. R. Fowles, W. T. Silfvast, and R. C. Jensen (Utah, University, Dept. of Physics, Salt Lake City, Utah).

IEEE Journal of Quantum Electronics, vol. QE-1, July 1965, p. 183, 184. 5 refs.

USAF-NSF-supported research.

Observation of laser oscillation in the visible region in pulsed cold cathode discharges, in plasma tubes internally coated with sulfur or phosphorus and containing various carrier gases. The wavelengths at which the laser action occurs correspond to transitions in the singly ionized states of the two elements. The results are summarized in tables which list the calculated wavelengths, tentative assignments of the transitions, and descriptions of the intensities. In every case, the observed wavelengths were within  $\pm 1 \text{\AA}$  of the calculated values.

R. A. F.

## A65-33380

OPTICAL GAIN AND LOSSES OF EPITAXIAL AND DIFFUSED GaAs INJECTION LASERS.

M. H. Pilkuhn, H. Rupprecht, and J. Woodall (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N.Y.).

IEEE Journal of Quantum Electronics, vol. QE-1, July 1965, p. 184. 7 refs.

ARPA-Navy-DOD-supported research.

Comparison between gain and losses of GaAs lasers fabricated by diffusion and those made by epitaxial techniques. Using the methods of Pilkuhn, Rupprecht, and Blum, the gain factor and the loss per unit length were obtained from the length dependence of the threshold current density. The results confirm the findings of Dousmanis and Nelson that epitaxial lasers have consistently lower values for the threshold current density at room temperature than

diffused lasers. At 77°K the laser losses seem to be identical, but the gain factor is slightly higher for epitaxial lasers. At room temperature the epitaxial lasers have a gain factor about seven times as great as diffused lasers; the losses are increased by a factor of 4.5. R. A. F.

#### A65-33415

##### EFFECT OF TRAPPED LIGHT ON THE OUTPUT OF A RUBY LASER.

J. Linn and J. Free (Korad Corp., Santa Monica, Calif.).

*Applied Optics*, vol. 4, Sept. 1965, p. 1099-1101. 7 refs.

Army-supported research.

Description of experiments which show that the observed near-field patterns of ruby lasers and the gain variations over the aperture of ruby amplifiers arise from competition between modes. The authors conclude that nonuniform spatial interaction between competing modes accounts for both the temporal (spiking) and spatial (near-field) output of ruby lasers. (Author) B. B.

#### A65-33416

##### EVALUATION OF SPECIALLY GROWN RUBY LASER RODS.

E. W. Sucov (Westinghouse Electric Corp., Research and Development Center, Pittsburgh, Pa.).

*Applied Optics*, vol. 4, Sept. 1965, p. 1107-1112. 21 refs.

Study of twelve ruby rods incorporating two kinds of controllable gross inhomogeneities (banding and lineage). Optical evaluation by means of interferographs and low-angle scattering measurements were compared with actual performance measurements. It is concluded that not enough information is available to predict the performance of a ruby laser rod from its manner of growth or from measures of passive optical homogeneity. Time-dependent measurement are suggested as being more useful, and a hypothesis to explain the differences in performance between various rods is proposed. (Author) B. B.

#### A65-33418

##### ALIGNMENT OF $\text{Cr}^{3+}$ IN RUBY.

G. F. Hull, Jr., J. T. Smith, and A. F. Quesada (Baird-Atomic, Inc., Cambridge, Mass.).

*Applied Optics*, vol. 4, Sept. 1965, p. 1117-1120. 7 refs.

USAF-supported research.

Alignment of  $\text{Cr}^{3+}$  in ruby by optically pumping a ruby sample with circularly polarized radiation, 6943 Å, from a high-power ruby laser. Alignment of  $\text{Cr}^{3+}$  is detected by the emf induced in a coil surrounding the ruby sample. Measurements of the percentage alignment and relaxation time of  $\text{Cr}^{3+}$  are obtained from oscillograms of the induced emf and of the circularly polarized radiation from the ruby laser. At room temperature the efficiency of alignment is several tens of percent and the relaxation time of  $\text{Cr}^{3+}$  is about 0.1 μsec. (Author) B. B.

#### A65-33419

##### DICHROIC CALCITE POLARIZERS FOR THE INFRARED.

T. J. Bridges and J. W. Kluver (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).

(Institute of Electrical and Electronic Engineers, Conference on Electron Device Research, 22nd, Ithaca, N. Y., June 24-26, 1964, Paper.)

*Applied Optics*, vol. 4, Sept. 1965, p. 1121-1125. 10 refs.

Discovery that crystalline calcite may be used as an excellent dichroic polarizer in certain regions of the IR between 2.5 and 16 μ where previously only rather unsatisfactory polarizers were available. The performance of the new polarizers is particularly good for radiation from the high-gain laser lines of helium-neon at 3.39 μ and helium-xenon at 3.507 μ, and their use has greatly assisted in the investigation of these lines. Some typical applications are the measurement of Zeeman effects, measurement of noise properties, use in modulators, circulators, and optical attenuators. The polarizer takes the form of a thin plate of calcite correctly cut from the crystal. For a 1-mm-thick piece measured at 3.507 μ, the minor principal attenuation is 1 db (to obtain the optical density, the db value is divided by 10). The major principal attenuation is 120 db, but, in practice, it is limited by scattering to around 80 db. The acceptance angle is about 30°. (Author) B. B.

#### A65-33430

##### A SOURCE OF SPIRAL FRINGES.

R. R. Shannon, R. E. Weekley (Itek Corp., Lexington, Mass.), and D. Shafer (Rochester, University, Institute of Optics, Rochester, N. Y.).

*Applied Optics*, vol. 4, Sept. 1965, p. 1193-1196.

USAF-supported research.

Observation of a single spiral rotating through several cycles in the fringe pattern obtained from a common type of interferometer when laser illumination is used. Such an interference pattern would indicate the presence of a very unusual discontinuity in the wavefront or in the surface generating the wavefront. It is shown that such a pattern may be generated in several ways and may be explained in a relatively simple way. The implications of this behavior for data reduction from interferograms are outlined. A simple demonstration of this effect is described. (Author) B. B.

#### A65-33516 #

##### RESONANT WAVES IN A FABRY-PEROT INTERFEROMETER.

Helmut K. V. Lotsch (Northrop Corp., Northrop Space Laboratories, Hawthorne, Calif.).

*Japanese Journal of Applied Physics*, vol. 4, June 1965, p. 435-444. 13 refs.

Investigation of the resonant waves of a Fabry-Pérot interferometer on the basis of standing-wave-type formations. This formulation leads to a homogeneous Fredholm integral equation whose kernel is real and symmetric when Cartesian coordinates are used, but it cannot be represented as a product of two independent functions. Therefore, the auxiliary problem of a system of two plane parallel strip mirrors of infinite length is considered. The corresponding integral equation depends on only one coordinate variable, but otherwise its characteristic features are identical with those of the equation which describes the Fabry-Pérot interferometer. The lowest-order eigenfunctions are computed by a numerical method. A model to construct the mode pattern as it is observed in a laser experiment if several eigenmodes are excited simultaneously is suggested. A phenomenon is discussed which predicts a doughnut-shaped pattern. It is believed that Siegman has already observed this anomalous mode pattern in experiments with a ruby laser. An internal aperture which limits the laser action in a Fabry-Pérot interferometer does not appreciably discriminate against higher-order eigenmodes. (Author) D. P. F.

#### A65-33517 #

##### A RUBY LASER WITH EXTERNAL MIRRORS OF LARGE SPACING.

Tadao Shimizu (Institute of Physical and Chemical Research, Microwave Physics Laboratory, Tokyo, Japan), Fujio Shimizu, Minato Kawaguti, and Koichi Shimoda (Tokyo, University, Dept. of Physics, Tokyo, Japan).

*Japanese Journal of Applied Physics*, vol. 4, June 1965, p. 445-451.

Study of the characteristics of a ruby laser when the separation between mirrors of the resonator is as long as 10.5 and 25.5 m. The experiments performed are the observation of beat signals between axial modes by an oscilloscope and Fabry-Pérot analysis of the spectrum. Relation between the two results is discussed. Mode selection effect due to the characteristics of its double resonator is found. (Author) D. P. F.

#### A65-33518 #

##### SPECTROSCOPY OF MERCURY-HELIUM DISCHARGE AND 6150 Å LASER OSCILLATION.

Norihito Suzuki (Shimadzu Seisakusho, Ltd., Kyoto, Japan).

*Japanese Journal of Applied Physics*, vol. 4, June 1965, p. 452-457.

Investigation of the mechanisms for the enhancement and laser oscillation of the 6150-Å line using a time-resolved spectroscopic study method. In the pulse excitation of a mercury discharge tube, several spectral lines of Hg II are enhanced by introducing helium into the tube. Especially the 6150-Å line of Hg II is enhanced strongly, and the laser oscillation of this line can be observed. From results of the measurements, it is concluded that the collision between the metastable helium ( $2^3\text{S}$ ) and the metastable mercury dominates the formation of the population inversion of the 6150-Å laser transition. (Author) D. P. F.

A65-33521

**A65-33521 #**

**STUDY ON SATURATION PROCESS BY ANOMALOUS DISPERSION OF RUBY LASER.**

Pil Hyon Kim and Susumu Namba (Institute of Physical and Chemical Research, Tokyo, Japan).

Japanese Journal of Applied Physics, vol. 4, June 1965, p. 469, 470.

Investigation of the rapid saturation phenomenon of a dye-absorbing solution placed in a laser optical cavity, Q, which through singlet-singlet transitions results in cavity increase and consequent production of a giant ruby laser pulse. To make clear the Q-switching mechanism in this method, the saturation process was studied by anomalous dispersion of the dye solution. Since the saturation process is rapid, it is difficult to measure the time variation of the light transmission. The dye was in the form of a prism of cryptocyanine (1,1' diethyl-4,4'-carbocyanine iodide), and a spectrum of a normal ruby laser was taken on Sakura 750 IR film. Since the wavelength of the absorption maximum of cryptocyanine is longer than that of the ruby laser, the spectral line of the latter should be deflected toward the long wavelength side by anomalous dispersion. Experimental results indicate that saturation occurs when a large fraction of the molecules are in metastable triplet states below excited singlet states; this process takes place by means of nonradioactive decay from excited singlet states.

D. P. F.

**A65-33536 #**

**SOME ASPECTS OF THE POINTING PROBLEM FOR OPTICAL COMMUNICATION IN SPACE.**

E. B. Moss (Douglas Aircraft Co., Inc., Advance Electronics Dept., Communications Branch, Santa Monica, Calif.).

(American Institute of Aeronautics and Astronautics, Annual Meeting, 1st, Washington, D.C., June 29-July 2, 1964, Paper 64-420.)

Journal of Spacecraft and Rockets, vol. 2, Sept.-Oct. 1965, p. 698-705.

**A65-33584 #**

**SOME REMARKS ON THE PROCESSES OCCURRING IN THE DECAYING PLASMA OF AN He-Ne PULSE DISCHARGE UNDER GENERATION CONDITIONS [NEKOTORYE ZAMECHANIA PO POVODU PROTSESSOV V RASPADAIUSHCHEISIA PLAZME IMPUL'SNOGO RAZRIADA NA SMESI He-Ne V USLOVIAXH GENERATSII].**

V. S. Egorov and A. S. Tibilov.

Optika i Spektroskopiia, vol. 18, Apr. 1965, p. 719-721. 6 refs. In Russian.

Supplementary data to previous studies of pulse-discharge plasma decay, obtained from observations of the generation processes in a He-Ne pulse laser. Some factors are indicated which further or inhibit generation.

V. Z.

**A65-33587 #**

**SELECTIVE REFLECTION AND DISPERSION PATTERNS NEAR THE RED RUBY LINES [SELEKTIVNOE OTRAZHENIE I VID DISPERSII VBLIZI KRASNYYKH RUBINOVYKH LINII].**

E. Ritschl', P. Glas, and I. Schwider (Institut Optiki i Spektroskopii, Berlin/Adlershof, East Germany).

(Vsesoiuznaia Konferentsiia po Spektroskopii, Minsk, Belorussian SSR, July 11, 1963.)

Optika i Spektroskopiia, vol. 18, Apr. 1965, p. 733-735. In Russian.

Observations of selective reflection in the red ruby lines at wavelengths from 694.0 to 693.4 mμ using a ruby laser as the light source in an arrangement allowing temperature variations from -10 to -150°C. Comparisons are made of the reflection from ruby (~ 5 x 10<sup>17</sup> Cr<sup>3+</sup> ions) and corundum (no impurity).

V. Z.

**A65-33770**

**COMPUTING AT THE SPEED OF LIGHT.**

Kendall Preston, Jr. (Perkin-Elmer Corp., Electro-Optical Div., Norwalk, Conn.).

Electronics, vol. 38, Sept. 6, 1965, p. 72-83. 13 refs.

Description of optical analog computers, which transpose variable inputs into spatial dimensions and operate on them simultaneously. With a laser as a light source, such computers are useful for antenna modeling and spectrum analysis. The analogy between a lens and a radar antenna is developed, and spectrum analysis and analyzer performance are discussed. Noise suppression by matched filters and noncoherent optical computers are considered, together with amplitude modulation, lens limitations, bulk scatter, input transducer choice, dynamic range limitations, and developmental input media.

B. B.

**A65-33809 #**

**APPLICATION OF LASER TO MEASUREMENTS OF HOMOGENEITY AND DIFFUSION LENGTH OF MINORITY CARRIERS IN SEMICONDUCTORS.**

E. Markowska and J. Świdorski (Polska Akademia Nauk, Instytut Podstawowych Problemów Techniki, Zakład Elektroniki, Warsaw, Poland).

Académie Polonaise des Sciences, Bulletin, Série des Sciences Techniques, vol. 13, no. 3, 1965, p. 257-260. 7 refs.

Description of techniques which use coherent light to measure diffusion lengths and specific resistivity in single crystals and finished semiconducting elements. The measuring system consisted of four basic components - (1) source of light with a set of filters, (2) an optical system to form a light spot, (3) a device for handling the sample, and (4) an electrical device for detecting signals emitted by the sample. The source of light consisted of a He-Ne laser, the light spot was formed by a MIM6 microscope, and the voltage on the sample was measured with a high-sensitivity potentiometer. The results obtained on measurements of specific resistivity and diffusion length are analyzed. The advantages of this laser technique are enumerated.

D. P. F.

**A65-33897**

**COHERENCE IN OPTICS [COHERENCE EN OPTIQUE].**

M. Françon (Paris, Université, Faculté des Sciences, Paris, France) and S. Slansky (Centre National de la Recherche Scientifique, Paris, France).

Paris, Centre National de la Recherche Scientifique, 1965. 79 p. In French.

This book is a brief survey of the theory of coherence in optics, including the concept of degree in coherence, coherence in quasihomochromatic light, and the effect of temporal coherence on the diffraction phenomena. The concepts of spatial and temporal coherence are presented; the relationship between the length of the wave trains and the sharpness of the emitted radiations, the length of the coherence and the time of the coherence are analyzed; and vibrations emitted by an atom are studied. Successive wave trains emitted by an atom, vibrations originating from two different atoms emitting on the same mean frequency, vibrations having different frequencies but originating from the same atom, and vibrations of the same frequency and originating in the same atom are considered. The representation of radiation from an incoherent light source and the concept of degree in partial coherence are discussed. The contrast of interference fringes in quasi-monochromatic light and the degree of coherence at two points illuminated by a quasi-monochromatic light source are analyzed. The coherence in the image of a nonpoint light source, partial coherence in polarization interferometers, and incoherent nonpoint sources yielding coherent light are covered. Finally, the point source is analyzed as a one-parameter phenomenon, two-parameter phenomena are noted, and the phenomenon of diffraction produced by a circular aperture is also discussed.

M. L.

**A65-34207**

**FOCUSED LASER-BEAM EXPERIMENT AND THE OSCILLATOR STRENGTH OF THE SWAN SYSTEM.**

M. Jeunehomme and R. P. Schwenker (Du Pont de Nemours and Co., Inc., Engineering Dept., Radiation Physics Laboratory, Wilmington, Del.).  
Journal of Chemical Physics, vol. 42, Apr. 1, 1965, p. 2406-2408. 7 refs.

Contract No. NASw-707.

Experimental investigation of a beam from a Q-spoiled ruby laser focused on a graphite block maintained under vacuum. The C<sub>2</sub> Swan system was produced and the fluorescence decay time is interpreted as the lifetime of the A <sup>3</sup>Π<sub>g</sub> state of C<sub>2</sub>. The lifetimes of four different vibronic levels of that state were measured. The variation of the electronic part of the transition moment over the nuclear coordinates is deduced from the spread of the lifetime values. The oscillator strength f(0, 0) for the Swan system is calculated to be  $(4.33 \pm 0.12) \times 10^{-3}$ . (Author) M.M.

#### A65-34552 #

MEASUREMENT OF THE TIME PARAMETERS OF A POWERFUL LASER WITH THE AID OF A PHOTODIODE [IZMERENIE VREMENNYKH PARAMETROV MOSHCHNOGO OPTICHESKOGO KVANTOVOGO GENERATORA PRI POMOSHCHI FOTODIODA]. R. V. Ambartsumian, N. G. Basov, P. G. Eliseev, V. S. Zuev, P. G. Kriukov, and Iu. Iu. Stoilov.  
Radiotekhnika i Elektronika, vol. 10, Sept. 1965, p. 1729, 1730. In Russian.

Description of a method of measuring the time parameters of a laser pulse with the aid of a GaAs photodiode. An estimate is made of the time constant of the photodiode used in the experiments. Measurements are made of the duration of a laser pulse irradiating the photodiode at room temperature and at 77°K. The time resolution of the photodiode is found to be in good agreement with the previously estimated time constant and is used to determine the lag of a laser pulse with respect to the moment of opening of a Kerr shutter. A. B. K.

#### A65-34606

##### FLAT-ROOF RESONATORS.

G. Toraldo di Francia (Florence, University, Institute of Physics, Florence, Italy).  
Applied Optics, vol. 4, Oct. 1965, p. 1267-1270. 9 refs. USAF-sponsored research.

Theoretical discussion of a microwave or laser resonator with flat-roof mirrors. When the angle of the roof is extremely small, on the order of  $10^{-3}$  rad for microwaves or  $10^{-3}$ - $10^{-6}$  rad for optics, this resonator has some features in common with the confocal resonator. (Author) M. F.

#### A65-34610

LASER GAIN MEASUREMENTS IN A XENON-KRYPTON DISCHARGE. H. Brunet (Compagnie Générale d'Electricité de Paris, Centre de Recherches, Département Recherches Physiques de Base, Marcoussis, Seine-et-Oise, France).

Applied Optics, vol. 4, Oct. 1965, p. 1354. 5 refs.

Analysis of the employment of two Brewster-type lasers in an oscillator-amplifier configuration to measure laser gain in a xenon-krypton discharge. The experimental facility is described, data are tabulated for several lines for which the gain was measured, and gain/unit length vs input signal level is plotted. (Author) M. F.

#### A65-34616

##### EFFECTS OF ABSORPTION OF LASER RADIATION ON METALS.

M. Iannuzzi and R. Williamson (Oxford, University, Engineering Laboratory, Oxford, England).

Nuovo Cimento, vol. 36, Apr. 16, 1965, p. 1130-1134. 5 refs.

Results of an experiment designed to observe the time correlation between laser pulses and laser-induced electron emission from metallic surfaces. Depending on the surface conditions, it was found that the delay of the electron emission ranged from  $3 \times 10^{-7}$  to less than  $10^{-8}$  sec, the limit of resolution of the laser used. An interpretation of the results is suggested. (Author) M. F.

#### A65-34662 #

##### VACUUM U. V. MEASUREMENTS OF HELIUM-NEON LASER DISCHARGE.

Norihito Suzuki (Shimadzu Seisakusho, Ltd., Kyoto, Japan).

Japanese Journal of Applied Physics, vol. 4, Apr. 1965, p. 285-291. 10 refs.

Investigation of the effect of the 600-Å emission band of He and the imprisonment of neon resonance lines on the operation of an He-Ne laser. Vacuum UV measurements and time-resolved spectroscopic measurements were made, and the influence of the vacuum UV emission on laser operations was investigated. It is concluded that the oscillation intensity of the 6328 Å laser is reduced by the emission of the helium-molecule 600-Å band and that the imprisonment of the cascade transitions of neon suppresses the laser operations. (Author) R. A. F.

#### A65-34663 #

ON THE VISIBILITY OF 8400 Å LIGHT FROM GaAs LASER DIODES. Yasuo Nannichi (Nippon Electric Co., Ltd., Fundamental Research Laboratory, Kawasaki, Japan).

Japanese Journal of Applied Physics, vol. 4, Apr. 1965, p. 308. 6 refs.

Investigation of the so-called "red glow" from GaAs laser diodes. More than 20 observers were able to see the red glow with the unaided eye at 60 amps. Observation through three filters of varying transmittance characteristics supported Kaynes and Quist's contention that the glow results from excitation of the eye by the intense 8400-Å IR line. There is evidence to indicate that GaAs laser light can damage the eyes permanently. It is therefore recommended that laser GaAs diodes not be observed directly. R. A. F.

#### A65-34665 #

##### LASER INDUCED PHOTOCONDUCTIVITY IN CdS CRYSTAL.

Katsumi Yoshino, Yasutaka Watanabe, and Yoshio Inuishi (Osaka University, Faculty of Engineering, Osaka, Japan).

Japanese Journal of Applied Physics, vol. 4, Apr. 1965, p. 312, 313.

Comparison of the photoconductivity induced in CdS by ruby-laser light with the photoconductivity induced by ordinary green light. The photoconductivity induced in CdS (band gap  $E_g = 2.45$  eV) by ordinary green light varied roughly in proportion to the intensity of the light; the photoconductivity induced in the CdS by light at 6943 Å from a ruby laser varied approximately in proportion to the square of the light intensity. This is seen to support Braunstein and Ockman's suggestion that the laser-induced photocurrent in CdS is due to double-photon absorption. R. A. F.

#### A65-34666 #

##### THE EMISSION PROCESS THROUGH DONOR STATES IN GaAs LASER DIODES.

Osamu Ohtsuki, Tsuyoshi Kotani, Yoshio Iwai, and Ichiro Tsurumi (Kobe Kogyo Corp., Kobe, Japan).

Japanese Journal of Applied Physics, vol. 4, Apr. 1965, p. 314, 315.

Discovery of two kinds of radiative transition process from observation of the emission spectrum of GaAs p-n junction laser diodes. The diodes were prepared by diffusing Zn into GaAs crystals containing Te impurities of concentrations  $2.0 \times 10^{17}$  and  $2.5 \times 10^{17}$  cm<sup>-3</sup>. Two main emission peaks were clearly observed at measured temperatures, but only in those diodes with the lower Te concentration. The observed shifts of emission-peak energy have two different kinds of temperature-dependence, which are plotted. It is concluded that the transitions from both the conduction-band and Te-donor states to Zn acceptor states must occur simultaneously in GaAs diodes made from crystal containing a critical value of Te donor concentration. R. A. F.

#### A65-34687

##### INTENSITY FLUCTUATIONS IN GaAs LASER EMISSION.

J. A. Armstrong and Archibald W. Smith (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N. Y.).

Physical Review, 2nd Series, Section A, vol. 140, Oct. 4, 1965, p. A155-A164. 27 refs.

## A65-34806

Measurement of the intensity fluctuations in the emission from various lasing and nonlasing modes of a cw GaAs laser. The measurements were made by two techniques - the coincidence-counting version of the Hanbury Brown-Twiss intensity interferometer and the single-detector excess-photon-noise technique. The two independent methods give excellent quantitative agreement. The intensity noise in the single lasing mode was studied as the laser was taken continuously through the threshold region; this has permitted observation of the gradual change in the statistical nature of the photon noise which occurs at laser threshold. Observations have also been made of correlations between the intensity fluctuations in the emission from different modes of the laser. The experimental observations of intensity fluctuations and correlations and their dependences on injection current can be understood in terms of the response of single or of coupled van der Pol oscillators to random-noise excitation. (Author) M. F.

### A65-34806 #

RELATION BETWEEN THE TRANSIENT LASER OSCILLATIONS AND THE PLASMA QUANTITIES IN A He-Ne GASEOUS LASER. Koichi Toyoda and Chiyo Yamanaka (Osaka University, Faculty of Engineering, Osaka, Japan). *Japanese Journal of Applied Physics*, vol. 4, Mar. 1965, p. 226, 227. 5 refs.

Measurement of the changes of electron density and collision frequency in the transient oscillation of IR and visible He-Ne lasers, using Takeda's (1963) S-band microwave impedance method with electric probes, with an aim to determining the relationship between the oscillations and the plasma parameters. The collision frequency was observed to increase greatly while the laser was oscillating. The results of the experiments suggest that the enhancement of the light intensity of the IR laser in the afterglow period is partly attributable to the decay of direct excitation for the  $1s$  level of Ne. It is also concluded that the visible laser can oscillate even at extremely high collision frequencies because the excitation by energetic electrons steadily supplies the population of the  $2^1S$  level of He.

R. A. F.

### A65-34807 #

OFF-AXIAL MODES IN CYLINDRICAL GLASS LASER RODS. Ryosuke Yokota and Hiroshi Imagawa (Tokyo Shibaura Electric Co., Ltd., Central Research Laboratory, Kawasaki, Japan). *Japanese Journal of Applied Physics*, vol. 4, Mar. 1965, p. 231, 232.

Observation of off-axial oscillations in laser rods of circular cross section. Far-field patterns of neodymium lasers showed clear axial modes, which are considered to be caused by the formation of closed light paths inside the laser rod.

R. A. F.

### A65-34904

VISUAL OBSERVATION OF INFRARED LASER EMISSION. L. S. Vasilenko, V. P. Chebotaev, and Iu. V. Troitskii (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Institut Radiofiziki i Elektroniki, Novosibirsk, USSR). (*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, Mar. 1965, p. 777, 778.) *Soviet Physics - JETP*, vol. 21, Sept. 1965, p. 513, 514. Translation.

[For abstract see Accession no. A65-24083 13-16]

### A65-34905

INVESTIGATION OF A NEON-HYDROGEN LASER AT LARGE DISCHARGE CURRENTS. V. P. Chebotaev and L. S. Vasilenko (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Institut Radiofiziki i Elektroniki, Novosibirsk, USSR). (*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, Mar. 1965, p. 779-781.) *Soviet Physics - JETP*, vol. 21, Sept. 1965, p. 515, 516. Translation.

[For abstract see Accession no. A65-24084 13-16]

### A65-34906

THE SPECTRUM AND TEMPORAL CHARACTERISTICS OF STIMULATED EMISSION IN  $\text{CaF}_2:\text{Sm}^{2+}$ . Iu. A. Anan'ev and B. M. Sedov. (*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, Mar. 1965, p. 782-790.) *Soviet Physics - JETP*, vol. 21, Sept. 1965, p. 517-523. 18 refs. Translation.

[For abstract see Accession no. A65-24085 13-16]

### A65-34909

EMISSION OF MONOPULSES OF COHERENT LIGHT BY A TWO-COMPONENT MEDIUM WITH NEGATIVE ABSORPTION. V. I. Borodulin, N. A. Ermakova, L. A. Rivlin, and V. S. Shil'diaev. (*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, Mar. 1965, p. 845-849.) *Soviet Physics - JETP*, vol. 21, Sept. 1965, p. 563-566. 8 refs. Translation.

[For abstract see Accession no. A65-24088 13-16]

### A65-34957 #

LASER-INDUCED TEMPERATURE RADIATION. Takashi Kushida (Tokyo Shibaura Electric Co., Ltd., Central Research Laboratory, Kawasaki, Japan). *Japanese Journal of Applied Physics*, vol. 4, Jan. 1965, p. 73, 74.

Observation of white light emission when a pulsed laser beam is focused on various materials as targets. Several characteristics of the emission (which is shown to be mainly due to the temperature radiation) were studied. Typical oscilloscope traces show the correlation between the laser output and the white light emission. A time correlation is observed, but there appears to be no intensity correlation between the output and the emission; this can be explained by the difference of the directionality in each laser spike. The spectra of the emissions were measured by the spectrophotometric method. A close agreement can be found with the blackbody radiation spectrum and hence the observed emission can be attributed mainly to the temperature radiation.

M. F.

### A65-35043 #

LASER OSCILLATION IN THE MIXTURES OF FREON AND RARE GASES. Mitsuyoshi Shimazu and Yasuzi Suzuki (Hitachi, Ltd., Central Research Laboratory, Tokyo, Japan). *Japanese Journal of Applied Physics*, vol. 4, May 1965, p. 381, 382. 5 refs.

Proposal of a mechanism for laser excitation in Freon-Ne and Freon-He mixtures, based on the dissociative excitation process, together with experimental and theoretical considerations of the quenching action of some gases. The experimental apparatus was essentially the same as that used by Shimazu and Suzuki in 1964. There are some repulsive electronic states which produce  $4p^2P_{3/2}^0$  as a dissociation product. The transitions arising from the lower state  $4s^2P_{1/2}$  have a high probability; therefore, an inversion of population density may be realized between  $4p^2P_{3/2}^0$  and  $4s^2P_{1/2}$  levels. An explanation for the quenching action of Ar, Kr, Xe, and  $\text{N}_2$  is given, based on dissociative excitation transfer with collisions between ground-state  $\text{Cl}_2$  molecules and the metastable atoms of these gases.

R. A. F.

### A65-35053

OUTPUT POWER AND ENERGY IN A Q-SWITCHED RUBY LASER WITH A SATURABLE ABSORBER. G. Potenza and A. Sona (Centro Informazioni Studi Esperienze, Laboratori, Milan, Italy). *Nuovo Cimento*, vol. 38, Aug. 1, 1965, p. 1438-1440. 6 refs. Research supported by the Consiglio Nazionale delle Ricerche. Experimental analysis of the emission characteristics of a Q-switched ruby laser with a saturable absorber. A  $3 \times 1/4$  in. ruby rod oriented at  $90^\circ$  was used as the active medium, and a cell

containing a solution of vanadium phthalocyanine was used as the saturable absorber. The ruby rod was pumped by a helical flash-lamp. Preliminary experiments were performed using a cell 3 cm thick inside the cavity with the end faces nearly parallel to the mirrors, followed by experiments with a cell inserted at the Brewster angle. The output energy and power were measured with photomultipliers for different values of concentration of the phthalocyanine solution. Curves are given illustrating the relationship between peak power and the cell absorption for different values of the pump energy. The power and energy dependence vs cavity length was examined.

D. P. F.

**A65-35061****MEASUREMENT OF LOCALIZED FLOW VELOCITIES IN GASES WITH A LASER DOPPLER FLOWMETER.**

J. W. Foreman, Jr., E. W. George, and R. D. Lewis (Brown Engineering Co., Inc., Research Laboratories, Huntsville, Ala.). *Applied Physics Letters*, vol. 7, Aug. 15, 1965, p. 77, 78. Contract No. NAS 8-5285.

Measurement of local flow velocities in a gas by means of a laser Doppler flowmeter. The essential elements of the optical system are shown schematically, and its mode of operation is described, together with a technique for measurement and the performance of auxiliary experiments. Flow velocities as measured by the direct and Doppler methods are graphed.

B. B.

**A65-35063****MODE-LOCKING EFFECTS IN AN INTERNALLY MODULATED RUBY LASER.**

Thomas Deutsch (Raytheon Co., Research Div., Waltham, Mass.). *Applied Physics Letters*, vol. 7, Aug. 15, 1965, p. 80-82. 9 refs. Contract No. AF 19(628)-4981.

Discussion of the observation of mode-locking effects using a ruby laser in both the normal and "Q-spoiled" modes of operation. The experimental apparatus is described and diagramed schematically, and experiments which were performed with it are discussed. It is concluded that with the proper cavity configuration self-locking can occur in ruby, just as it does in gas lasers. The outputs of ruby lasers having various modulations and of a Q-switched laser without modulation are graphed.

B. B.

**A65-35066****STIMULATED EMISSION FROM 4.3% ABUNDANT  $\text{Cr}^{50}$  IONS IN RUBY.**

L. W. Riley, M. Bass, and E. L. Hahn (California, University, Physics Dept., Berkeley, Calif.). *Applied Physics Letters*, vol. 7, Aug. 15, 1965, p. 88-90. NSF-Navy-supported research.

Outline of the observation of stimulated emission from the  $\text{Cr}^{50}$  ions in a Q-spoiled ruby laser. Experimental equipment used and results obtained are described, and microdensitometer traces of the ruby laser  $R_1$  lines for burst operation and Q-spoiled operation are graphed.

B. B.

**A65-35067****HOLOGRAPHIC PHOTOGRAPHY OF HIGH-SPEED PHENOMENA WITH CONVENTIONAL AND Q-SWITCHED RUBY LASERS.**

R. E. Brooks, L. O. Heflinger, R. F. Wuerker, and R. A. Briones (Thompson Ramo Wooldridge, Inc., Systems Group, Redondo Beach, Calif.).

*Applied Physics Letters*, vol. 7, Aug. 15, 1965, p. 92-94. Research supported by Thompson Ramo Wooldridge, Inc.; Contract No. AF 33(615)-1035.

Study of the production of two-beam holograms of high-speed events by the radiation from a pulsed ruby laser operated either in the single pulse  $\sim 2$ -J,  $\sim 60$ -nsec half-width Q-switched mode, or in the conventional  $1/2$ -msec duration spiking mode. The apparatus used to produce the pulsed holograms is shown schematically, and its mode of operation is explained.

B. B.

**A65-35068****THERMAL EFFECTS IN OPTICALLY PUMPED LASER RODS.**

R. L. Townsend, C. M. Stickley, and A. D. Maio (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Bedford, Mass.).

*Applied Physics Letters*, vol. 7, Aug. 15, 1965, p. 94-96. 11 refs.

Discussion of the results of a study of thermal distortion, expansion, and scattering observed in ruby and glass laser rods both during and after the pump flash. The experimental equipment and test procedures are described, and test results and conclusions to be drawn are outlined. A method of achieving low beam divergence and of balancing out distortions due to pump-light absorption is given, together with a technique of pumping the laser uniformly and shielding it from the IR.

B. B.

**A65-35069****UV LASER EMISSION BY CRYSTAL EXCITONS.**

E. L. Fink (General Dynamics Corp., General Dynamics/Pomona, Physics and Infrared Section, Pomona, Calif.).

*Applied Physics Letters*, vol. 7, Aug. 15, 1965, p. 103-106. 13 refs.

Discussion of experimental studies of the stimulated emission of UV radiation in optically pumped potassium bromide single crystals. The high radiative quantum efficiency, Stokes shift, and strong absorption characteristics occurring in the exciton radiative transitions in alkali halides make these crystals candidates for laser emitters. Fabrication and operation of the experimental equipment are detailed, and the method of spectral measurement is described. It is concluded that the observed laser emission is consistent with an exciton scheme of population inversion devised for the alkali halides.

B. B.

**A65-35118****MORE POWER TO THE LASER - WITH Q SWITCHING.**

Joseph I. Masters (Technical Operations, Inc., Burlington, Mass.). *Electronics*, vol. 38, Oct. 18, 1965, p. 91-95.

Description of active and passive Q switches (shutter-like devices for increasing the stored pumping energy of lasers and inhibiting their resonance for periods of up to  $10^{-3}$  sec with subsequent peak laser excitation and discharge, resulting in gigawatt pulses). The quality factor  $Q = 2\pi/\lambda (1-r)$ , where  $\lambda$  is the resonator length,  $\lambda$  is the wavelength, and  $r$  is an overall reflectivity. A Q switch prevents lasing momentarily while the laser stores up pumping power; it then reverses its inhibitory characteristics which produces a condition of high Q and high inversion level resulting in the emission of giant pulses. Active Q-switch systems such as the Kerr cell and the spinning prism are described, in which shutter transparency is made to coincide with peak excitation of the laser rod. Passive Q switches are nonlinear components consisting of optically flat fractional light absorbers. The materials include thin organic dye films, Jena glasses, organic solutions, and doped glass. The process is one in which the absorption of laser energy of a sufficient power level causes the absorption coefficient of the passive element to decrease, almost to zero. In this position the Q switch or shutter is open.

D. P. F.

**A65-35195****THE GROUND RADIO STATION AT RAISTING FOR TELECOMMUNICATION WITH COMMUNICATIONS SATELLITES [DIE ERDE-FUNKSTELLE RAISTING FÜR DEN NACHRICHTENVERKEHR ÜBER FERNMELDESATELLITEN].**

M. Schönfeld (Deutsche Bundespost, Erdfunkstelle, Raisting, West Germany).

*Luftfahrttechnik Raumfahrttechnik*, vol. 11, Sept. 1965, p. 230-237. 14 refs. In German.

Description of the radio station facilities at Raisting, in Upper Bavaria, West Germany and brief review of the principles of telecommunications with satellites. System noise temperature is defined and a numerical example is given for a maser receiving system. Antenna gain and satellite space damping are discussed. The main installation at Raisting consists of two parabolic antennas (25-m wideband and 9-m narrow band) with associated tracking, receiving, and transmitting systems. The 25-m paraboloid employs a digital computerized system for automatic tracking, and the receiving facilities incorporate a maser. At a frequency of 4 Gc, antenna gain is 58 db. Capacity of the transmitter is 2 kw maximum at 6 Gc. A 49-m-diam radome supported by compressed air houses the antenna and associated systems.

D. P. F.

**A65-35279**

**DIFFRACTION SYNCHRONIZATION OF OPTICAL MASERS.**  
N. G. Basov, E. M. Belenov, and V. S. Letokhov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).  
(Akademiia Nauk SSSR, Doklady, vol. 161, Mar. 21, 1965, p. 556-559.)  
Soviet Physics - Doklady, vol. 10, Sept. 1965, p. 236-238. 8 refs.  
Translation.

Consideration of the synchronized generation of radiation by all semiconductor elements of a laser system with radiative mirrors caused by diffraction of the electromagnetic field. That regime of synchronized generation of the fundamental TEM<sub>00</sub> oscillation is considered most desirable for which the beam divergence is minimum and determined entirely by the size of the radiative mirror. Conditions for the existence, stability, and negativity of this regime are discussed.  
R. A. F.

**A65-35312****PROPOSED GAS MASER PUMPING SCHEME FOR THE FAR INFRARED.**

Willard H. Wells (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).  
Journal of Applied Physics, vol. 36, Sept. 1965, p. 2838-2843.  
11 refs.

Proposal of a scheme that is analogous to the operation of a heat engine for exciting maser action in the far infrared and sub-millimeter parts of the spectrum. A beam of hot molecules interacts through distant collisions with a cold gas of another species at very low pressure. Certain energy levels in the hot gas are cooled faster than others owing to coincidental resonances in the spectra of the two gases. In the partially cooled nonequilibrium state, population inversions are possible in the hot species. To demonstrate feasibility, the interaction between pure rotational states of HCl and HF is discussed in detail. Barring unforeseen experimental difficulty - e.g., chemical activity of HF - the Schawlow-Townes condition for maser action can be satisfied by the  $J = 3 \rightarrow 2$  transition in HF at 123.1 cm<sup>-1</sup>, or 81.25  $\mu$ . (Author) M. F.

**A65-35315****BEAM DIVERGENCE AND FAR-FIELD PATTERNS OF RUBIES OF VARYING OPTICAL QUALITY.**

C. M. Kellington and M. Katzman (U.S. Army, Electronics Command, Electronics Laboratories, Fort Monmouth, N.J.).  
Journal of Applied Physics, vol. 36, Sept. 1965, p. 2910-2914.  
15 refs.

Measurement of beam divergences and photography of far-field patterns for 37 ruby rods of different quality. The growth with pumping power of the most intense portion of the laser beam was measured for two rods of very different quality. An autocollimator reticle image was photographed after passage through each rod. The correlation of beam divergence with optical parameters is discussed.  
(Author) M. F.

**A65-35358****A STABLE, SINGLE-FREQUENCY RF-EXCITED GAS LASER AT 6328 Å.**

J. A. Collinson (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).  
Bell System Technical Journal, vol. 44, Sept. 1965, p. 1511-1519.  
26 refs.

Design and construction of a number of 6328-Å RF-excited He-Ne lasers, with special attention to maximizing CW power in a single longitudinal and transverse mode. A single-mode output power of 1.6 mw has been obtained. Some novel features of the cavity structure provide good intrinsic frequency stability. The details of design and operation are given.  
(Author) M. F.

**A65-35784 #****DYNAMICS OF LASER EMISSION WITH VARIABLE LOSSES. II [DINAMIKA VIPROMINUUVANNIA LAZERA ZI ZMINNIMI VTRATAMI. II].**

G. Iu. Buriakivskii and V. S. Mashkevich (Akademiia Nauk Ukrain's'koi RSR, Institut Fiziki, Kiev, Ukrainian SSR).  
Ukrains'kii Fizicheskii Zhurnal, vol. 10, Apr. 1965, p. 398-409.  
In Ukrainian.

Discussion of laser emission dynamics, extending a previous study of a large initial overpopulation to a laser with a relatively low level of initial overpopulation. Kinetic equations are applied in one-mode approximation assuming that the system is homogeneous and losses are a linear function of time. Generation of giant oscillations is found to be possible. Conditions are analyzed to obtain a maximum emission output from such oscillations.  
V. Z.

**A65-35786 #****STUDY OF THE PERFORMANCE OF A RUBY LASER WITH A MODULATED Q-FACTOR [DOSLIDZHENNIA ROBOTI RUBINOVOGO OPTICHNOGO KVANTOVOGO GENERATORA Z MODUL'OVANOIU DOBROTNISTIU].**

Iu. V. Baiborodin, S. A. Garazha, V. I. Kravchenko, and N. I. Spizhova.  
Ukrains'kii Fizicheskii Zhurnal, vol. 10, Apr. 1965, p. 455-457.  
In Ukrainian.

Results of a study of the dynamic and static characteristics of a laser with a modulated Q-factor. The dependence of the pumping energy threshold on the angle of resonator mirror disalignment is determined. The effects of the resonator length and mirror transparency on laser performance are analyzed. The operation mode of a laser with a prismatic shutter is investigated.  
V. Z.

**A65-35842 #****INDUCED RADIATION IN GALLIUM ARSENIDE DUE TO OPTICAL EXCITATION [INDUTSIROVANNOE IZLUCHEENIE V ARSENIDE GALLIIA PRI OPTICHESKOM VOZBUZHDENII].**

N. G. Basov, A. Z. Grasiuk, and V. A. Katulin (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).  
Akademiia Nauk SSSR, Doklady, vol. 161, Apr. 21, 1965, p. 1306, 1307. 8 refs. In Russian.

Preliminary investigation of induced radiation and generation in a GaAs semiconductor crystal excited by the light from a ruby laser with Q-modulation. The sample used in the experiment was a GaAs single-crystal measuring 2 by 1 mm, and 0.5 mm thick. The radiation induced in this sample by the laser beam was recorded. The results are discussed, and the spectral lines of the induced radiation are given.  
R. A. F.

**A65-35863 #****EFFECT OF NOISE RADIATION ON THE PERFORMANCE OF A RUBY LASER [VLIANIE RADIATSII SHUMA NA RABOTU RUBINOVOGO KVANTOVOGO GENERATORA].**

B. I. Stepanov, A. N. Rubinov, and S. A. Mikhnov (Akademiia Nauk Belorusskoi SSR, Institut Fiziki, Minsk, Belorussian SSR).  
Akademiia Nauk SSSR, Doklady, vol. 162, June 11, 1965, p. 1030-1033. 11 refs. In Russian.

Discussion of "noise radiation" of a ruby laser consisting of increased luminescence and laterally dispersed generation; such radiation directly shows the radiation losses of a laser and is one of the laser's most important characteristics. A method is proposed for measuring noise intensity from energy level populations determined by experiments and from relative values of pumping power.  
V. Z.

**A65-35866 #****PROBLEM OF VARIATIONS IN THE RUBY-LASER EMISSION SPECTRUM DURING THE PROCESS OF GENERATION [K VOPROSU OB IZMENENII SPEKTRA IZLUCHEENIA RUBINOVOGO LAZERA V PROTSESSE GENERATSII].**

A. M. Kubarev and V. I. Piskarev (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorki, USSR).  
Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, May 1965, p. 1233-1236. 5 refs. In Russian.

Experimental determination of the correlation factor for induced radiation frequency shifts and crystal temperature variations in a ruby laser. The results are in fair agreement with values calculated using McCumber and Sturge's expressions. It is indicated that, apart from temperature variations, other factors seem to be involved, one of which is a possibly inadequate Q-factor for the resonator.  
V. Z.

**A65-35868 \***

THEORY OF GAS LASERS [K TEORII GAZOVYKH LAZEROV].  
A. K. Popov (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Institut Fiziki, Krasnoyarsk, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, May 1965, p. 1279-1282. 7 refs. In Russian.

Solution of the problem of gas laser emission by the methods of semiclassical theory. The dependence of the density of the induced emission field on resonator parameters, the relaxation characteristics of the system, and atom excitation probability in a gas discharge plasma per unit time are determined. The motion of emitting particles, the degeneracy of energy levels, the excitation mechanism of the lower level, and the random orientation of the dipole moments in a gas laser are discussed. V.Z.

The extended system is of the Thomson type and can be effectively analyzed by the small-parameter method. Numerical examples of laser operating conditions based on the extended relationships are given. V.Z.

**A65-35931 #**

EXPERIMENTAL STUDY OF GAS LASER MODULATION [EKSPERIMENTAL'NOE ISSLEDOVANIE MODULIATSII GAZOVOGO OPTICHESKOGO KVANTOVOGO GENERATORA].

I. G. Goncharov (Moskovskii Inzhenerno-Fizicheskii Institut, Moscow, USSR).

*Radiofizika*, vol. 8, no. 2, 1965, p. 411, 412. In Russian.

Brief note on an experimental study of He-Ne laser operation at  $\lambda = 0.63 \mu$ , using circuits which permit discharge-current modulation by both positive and negative voltage pulses. It is found that light generated by such lasers can be modulated by 40-kc pulses and that light generation by 1- and 2- $\mu$ -sec pulses fails at dc levels below  $I_{\text{thresh.}} = 10$  to 15  $\mu$ A. V.Z.

**A65-35875 \***

LASER WITH A NEODYMIUM-GLASS-MODULATED Q-FACTOR [OPTICHESKII KVANTOVYI GENERATOR S MODULIATSIEI DOBROT-NOSTI NA NEODIMOVOM STEKLE].

N. G. Basov, V. S. Zuev, and Iu. V. Senatskii (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, June 1965, p. 1562-1564. 5 refs. In Russian.

Description of a Nd-glass laser producing two 25- to 43-nsec light pulses with a combined energy of 8 joules. A system employing a rotating prism is used for switching the Q-factor of the resonator. A diagram is included which shows the laser operation. A method is proposed to reduce the pulse width. V.Z.

**A65-36011 #**

THEORY OF A CIRCULAR DIELECTRIC RESONATOR. II [K TEORII DIELEKTRICHESKOGO KRUGOVOGO REZONATORA. II].

A. M. Goncharenko and B. A. Sotskii (Akademiia Nauk Belorusskoi SSR, Institut Fiziki, Minsk, Belorussian SSR).

*Akademiia Nauk BSSR, Doklady*, vol. 14, June 1965, p. 360-363. 8 refs. In Russian.

Discussion of the behavior of a circular dielectric resonator under certain critical operating conditions. Previously derived general expressions for the performance and energy losses of a finite-size resonator are extended to these cases. The conclusion is drawn that only the lower axial oscillations may arise at threshold levels of pumping. Nonaxial modes will also arise in a broad beam at higher pumping levels. V.Z.

**A65-35877 #**

HEATING OF SAMPLES BY FOCUSING THE EMISSION OF A LASER [NAGREV VESHCHESTVA PRI FOKUSIROVKE IZLUCHENIIA OPTICHESKOGO KVANTOVOGO GENERATORA].

R. V. Ambartsumian, N. G. Basov, V. A. Boiko, V. S. Zuev, O. N. Krokhin, P. G. Kriukov, Iu. V. Senatskii, and Iu. Iu. Stoilov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, June 1965, p. 1583-1587. 12 refs. In Russian.

Discussion of the high-temperature heating which may be achieved when the beam of a powerful laser is focused at the surface of a substance. The emission spectrum of lithium is generated by focusing laser radiation at the surface of a solid lithium sample. The technique is seen to be effective in producing a high-temperature plasma. V.Z.

**A65-36013 #**

DETERMINATION OF THE LOSS PARAMETERS IN A RUBY LASER [OPREDELENIE PARAMETROV POTERI KVANTOVOGO GENERATORA NA RUBINE].

B. I. Stepanov, A. N. Rubinov, and S. A. Mikhnov (Akademiia Nauk Belorusskoi SSR, Institut Fiziki, Minsk, Belorussian SSR).

*Akademiia Nauk BSSR, Doklady*, vol. 14, June 1965, p. 367-371. 10 refs. In Russian.

Derivation of an experimental method for determining the radiation scattering factor for a ruby laser. The method is based on the measurement of the populations of the energy levels during light generation. V.Z.

**A65-35919 #**

EFFECT OF A FINE SPLITTING OF THE  $\text{Cr}^{+3}$  LOWER LEVEL IN A RUBY ON CERTAIN COHERENT RADIATION CHARACTERISTICS [O VLIYANII TONKOGO RASSHCHEPLENIIA NIZHNEGO UROVNIA  $\text{Cr}^{+3}$  V RUBINE NA NEKOTORYE KHARAKTERISTIKI KOHERENTNOGO IZLUCHENIIA].

G. I. Freidman (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

*Radiofizika*, vol. 8, no. 2, 1965, p. 272-284. 12 refs. In Russian.

Derivation of truncated equations describing the coherent radiation of excited chromium ions in a ruby situated in a traveling wave resonator, taking into account the fine splitting of the chromium-ion lower level. It is shown that splitting changes the mean radiation frequency during a transient process, a phenomenon observed experimentally by Kubarev and Piskarev. V.Z.

**A65-36050 #**

STRUCTURE OF THE RADIATION FIELD OF A LASER WITH SPHERICAL MIRRORS [STRUKTURA POLIA IZLUCHENIIA GAZOVOGO LAZERA SO SFERICHESKIMI ZERKALAMI].

S. G. Zeiger, N. I. Kaliteevskii, E. E. Fradkin, and M. P. Chaika.

*Optika i Spektroskopiia*, vol. 19, Aug. 1965, p. 255-263. In Russian.

Experimental and theoretical study of the intensity distribution of laser radiation immediately after leaving the laser and after focusing with a lens. The fraction of radiant energy that can be converged within a given angle by means of two simple lenses is estimated. Optimum focusing conditions are established, taking into account incoherence. V.Z.

**A65-35930 #**

MODES OF LASER OPERATION IN THE PRESENCE OF AN ABSORBING IMPURITY [REZHIMY V KVANTOVOM GENERATORE PRI NALICHII POGLOSHCHAIUSHCHEI PRIMESI].

N. D. Voropaev and A. N. Oraevskii (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Radiofizika*, vol. 8, no. 2, 1965, p. 409-411. In Russian.

Discussion of a two-level laser model with an impurity which absorbs radiation at operating frequencies. The system of equations which describes the resonator fields and the active medium is extended to include equations describing the effects of the impurity.

**A65-36051 #**

PROBLEM OF THRESHOLD POWER OF AN OPTICALLY MIS-ALIGNED LASER [K VOPROSU O POROGOVOI MOSHCNOSTI LAZERA S NARUSHENNOI OPTICHESKOI IUSTIROVKOI].

I. A. Rom-Krichevskaya, A. M. Ratner, and A. V. Meshcheriakov. *Optika i Spektroskopiia*, vol. 19, Aug. 1965, p. 264-269. 6 refs. In Russian.



Investigation of the threshold pumping power of an optically misaligned solid-state laser. It is shown that the effect of misalignment on the threshold power may be compensated by a lens set in the resonator coaxially with the active medium. The conditions of the compensation are defined and the conclusions are drawn that (1) using a lens, optically inhomogeneous crystals may be employed in lasers at ray deflection angles  $< d/2F$ , and (2) a resonator with two plane mirrors and a lens is superior to an equivalent optical system of coaxial spherical reflectors. V. Z.

**A65-36053 #**

EFFECT OF MIRROR MISALIGNMENT ON LOSSES IN FABRY-PEROT RESONATORS [VLIANIE RAZ'USTIROVKI ZERKAL REZONATORA TIPA FABRY-PERO NA EGO POTERI]. M. P. Vaniukov, V. I. Isaenko, V. P. Kalinin, and V. V. Liubimov. *Optika i Spektroskopiia*, vol. 19, Aug. 1965, p. 286, 287. In Russian.

Results of the experimental determination of losses in Fabry-Perot resonators (500, 1200, and 2800 mm long; 4, 6, 10, and 15 mm in diameter) caused by mirror misalignment angles of 1 to 2'. The losses were found by comparing the threshold pumping energies at various misalignment angles. V. Z.

**A65-36055 #**

LUMINESCENCE AND ABSORPTION IN AN EXCITED RUBY [LIUMINESSENTSIYA I POGLOSHCHENIE VOZBUZHDENNOGO RUBINA].

M. D. Galanin, V. N. Smorchkov, and Z. A. Chizhikova. *Optika i Spektroskopiia*, vol. 19, Aug. 1965, p. 296-298. In Russian.

Investigation of the energy losses in a ruby laser due to evolution of heat following transitions from  ${}^2E$  levels to higher levels during optical pumping from broad-spectrum conventional sources. The relation between the energy absorption and population inversion is discussed. The techniques of measuring energy absorption and luminescence is described. The results are seen to be tentative. V. Z.

**A65-36058 #**

GENERATION OF A POWERFUL PULSE OF RUBY LASER EMISSION BY AN ULTRASONIC TRAVELING-WAVE DIFFRACTION MODULATOR [FORMIROVANIE MOSHCHNOGO IMPUL'SA IZLUCHENIYA RUBINOVOGO OKG S POMOSHCH'YU DIFRAKTSIONNOGO MODULIROVANNOL' UL' TRAZVUKOVOI VOLNE].

I. I. Adrianova, Iu. V. Popov, and V. E. Terent'ev.

*Optika i Spektroskopiia*, vol. 19, Aug. 1965, p. 307-310. In Russian.

Use of a diffraction modulator set between the ruby and the external mirror of a laser as an optical shutter to obtain enhanced emission pulses by instantaneously opening the shutter at a moment of maximum energy accumulation in the ruby. A block diagram of the experimental setup and oscillograms of such controlled pulses are presented. V. Z.

**A65-36095**

PRODUCTION OF COHERENT RADIATION BY ATOMS AND MOLECULES.

Charles H. Townes (Massachusetts Institute of Technology, Cambridge, Mass.).

(Nobel Foundation, Lecture, Stockholm, Sweden, Dec. 11, 1964.) *Science*, vol. 149, Aug. 20, 1965, p. 831-841. 65 refs.

Review of the history and development of molecular amplification by stimulated emission of radiation. The basic thermodynamic reasoning prerequisite to the understanding and control of stimulated emission is explained. The basic principles and development of the first molecular-beam masers are described, together with their earliest applications as clocks and amplifiers. The development of optical and IR lasers - solid-state, gas-discharge, and semiconductor - is discussed. The various types of lasers currently used, together with their limitations, are compared. Some of the applications of lasers to scientific research in spectroscopy, nonlinear optics, and the measurement of time and length are considered. Some possibilities of phonon masers are explored. R. A. F.

**A65-36219**

NONLINEAR OPTICS [L'OPTIQUE NON LINEAIRE].

J.-C. Canit (E.P.C.I., Laboratoire d'Optique Physique).

*Journal de Physique*, vol. 26, July 1965, p. 433-440. 82 refs. In French.

Examination of nonlinear phenomena microscopically to discover their origin and macroscopically to study the linking between incident radiation and induced radiation. The timing of light sources of very high power permits investigations into the field of optics where phenomena no longer depend linearly on the electric or magnetic fields. In particular, the polarization of the dielectric can be expressed as a quadratic function of the electric field which leads to the emission of a harmonic radiation of the incident radiation. Theoretically these phenomena are as yet relatively unknown and often difficult to understand. On the experimental side, many experiments have been carried out, searching for favorable conditions obtaining the second harmonic, of systematic studies of substances which permit high proportions of the second harmonic to be obtained, and of varied research with a view to obtaining a better understanding of nonlinear phenomena. (Author) M. F.

**A65-36356**

LIMITING CROSS SECTION OF LASER EMISSION BEAM.

N. G. Basov, E. M. Belenov, and V. S. Letokhov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Akademiia Nauk SSSR, *Doklady*, vol. 161, Apr. 1, 1965, p. 799-801.)

*Soviet Physics - Doklady*, vol. 10, Oct. 1965, p. 311-313. 5 refs. Translation.

[For abstract see Accession no. A65-24879 14-16]

**A65-36358**

$\text{CaF}_2:\text{Dy}^{2+}$  LASER.

V. V. Kostin, T. M. Murina, A. M. Prokhorov, and V. T. Udovenchik (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Akademiia Nauk SSSR, *Doklady*, vol. 161, Apr. 1, 1965, p. 806-809.)

*Soviet Physics - Doklady*, vol. 10, Oct. 1965, p. 317-319. 8 refs. Translation.

[For abstract see Accession no. A65-24881 14-16]

**A65-36359**

8-CM TRAVELING-WAVE MASER FOR RADIO ASTRONOMY INVESTIGATIONS.

L. I. Matveenko, G. S. Mizezhnikov, M. M. Mukhina, and V. B. Shteinsleiger.

(Akademiia Nauk SSSR, *Doklady*, vol. 161, Apr. 1, 1965, p. 810-812.)

*Soviet Physics - Doklady*, vol. 10, Oct. 1965, p. 320-322. Translation.

[For abstract see Accession no. A65-24882 14-16]

**A65-36361**

CONTINUOUS SOLAR LASER USING  $\text{Dy}^{2+}$  IN  $\text{CaF}_2$ .

A. A. Kaminskii, L. S. Kornienko, and A. M. Prokhorov (Moskovskii Gosudarstvennyi Universitet, Institut Iadernoi Fiziki; Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Akademiia Nauk SSSR, *Doklady*, vol. 161, Apr. 11, 1965, p. 1063, 1064.)

*Soviet Physics - Doklady*, vol. 10, Oct. 1965, p. 334, 335. Translation.

Description of a  $\text{CaF}_2:\text{Dy}^{2+}$  laser using solar radiation for excitation and operating at 77°K. The solar radiation is collected by a standard 450-mm aluminized glass mirror taken from a movie projector. A conical condenser of optically homogeneous fluorite is used to transfer the solar radiation to the laser. The condenser and the liquid are situated in a cryostat with pure liquid nitrogen. The power of this laser is estimated to be several microwatts.

P. K.

**A65-36362****INDUCED RADIATION IN OPTICALLY EXCITED GALLIUM ARSENIDE.**

N. G. Basov, A. Z. Grasiuk, and V. A. Katulin (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR).

(Akademiia Nauk SSSR, Doklady, vol. 161, Apr. 21, 1965, p. 1306, 1307.)

Soviet Physics - Doklady, vol. 10, Oct. 1965, p. 343, 344. 9 refs. Translation.

Review of work on the induced radiation and laser action of a GaAs single crystal excited by the light from a Q-modulated ruby laser. A liquid-nitrogen-cooled GaAs specimen was irradiated by a ruby laser pulse, and recombination radiation centered about 8365 Å was observed. The specimen was excited by the Stokes component of ruby laser radiation, combination-scattered in liquid nitrogen to produce a monochromatic beam at 8281 Å. P. K.

**A65-36361 #**

**INTERACTION BETWEEN A MOLECULAR BEAM AND THE ELECTROMAGNETIC FIELD OF A RESONATOR. II - STEADY-STATE OSCILLATIONS OF A MOLECULAR BEAM LASER WITH INHOMOGENEOUS FIELD [VZAIMODEISTVIE MOLEKULIARNOGO PUCHKA S ELEKTROMAGNITNYM POLEM REZONATORA. II - STATSIONARNYE KOLEBANIYA MOLEKULIARNOGO GENERATORA S NEODNORODNYM POLEM].**

V. B. Tsaregradskii (Gor'kovskii Gosudarstvennyi Universitet, Gorki, USSR).

Radiofizika, vol. 8, no. 3, 1965, p. 504-512. 8 refs. In Russian.

Derivation of expressions describing the polarization of a monokinetic molecular beam in an electromagnetic field. The expressions are used to analyze the steady-state oscillations of a molecular beam laser with an inhomogeneous sinusoidal field in its resonator. The amplitude and frequency characteristics of the beam laser are determined. It is shown that a beam laser with certain parameters has two limiting cycles with different frequencies of oscillations. V. Z.

**A65-36703 =****MODE DEGENERACY-DIPS ON OUTPUT OF GASLASER.**

Masanobu Yamanaka, Mamoru Nakasugi, Yoshihiro Ohtsuka, and Hiroshi Yoshinaga (Osaka University, Dept. of Applied Physics, Osaka, Japan).

Japanese Journal of Applied Physics, vol. 4, July 1965, p. 548, 549.

Description of some experiments to test the equation for expressing the mode degeneracy observed when resonant frequencies of a gas laser working at maximum power are mutually coincident for certain critical combinations of mirror curvatures and separations. This mode degeneracy results in reduced output power. The equation was tested by using a 6328 Å, rf excited, He-Ne gas laser with Brewster-angle windows and external mirrors. Three pairs of mirrors were used with different radii of curvature; the latter were measured by a simple optical method. Output power was measured with a calibrated photoelectric cell. The mirror spacings corresponding to the dips, which were calculated from the equation for mode degeneracy, are tabulated. The observed dips were centered at mirror separations which differed by less than 1% from the calculated values. D.P.F.

**A65-36712 #****ON THE STIMULATED AMPLIFICATION OF LIGHT.**

Tieh-Chen Li and Zhen-He Zhu (Academia Sinica, Peking, Communist China).

Acta Physica Sinica, vol. 21, June 1965, p. 1276-1292. 12 refs. In Chinese.

Solution for the simultaneous set of nonlinear equations for photon transport and population inversion in an active medium based upon the pumping effect. The analytical expressions of the space-time distribution function of inverted populations and photon density are then obtained for an arbitrary initial distribution of inverted populations. A single or a series of square pulse inputs are discussed. Moreover, the effects of the incidence of a very intense beam on the steady-state operation of the laser are also investigated. The perturbation method may be used, under certain conditions, to derive the formulas for photon density and inverted population density

in lasers. Calculations are made using the ruby laser as an example, and it is shown that the incidence of a very intense beam may possibly find application to the strengthening of giant pulses.

D.P.F.

**A65-36787 #**

**COHERENT EMISSION OF GaAs LUMINESCENT DIODES WITH A TRIANGULAR RESONATOR [KOGERENTNOE IZLUCHENIE IZ GaAs LUMINESSENTNYKH DIODOV S TREUGOL'NYM REZONATOROM].**

E. A. Poltoratskii, V. M. Stuchebnikov, and A. E. Iunovich (Moskovskii Gosudarstvennyi Universitet, Fizicheskii Fakul'tet, Moscow, USSR).

Zhurnal Tekhnicheskoi Fiziki, vol. 35, Aug. 1965, p. 1516-1521. 15 refs. In Russian.

Preparation of GaAs luminescent diodes with triangular resonators that produce coherent emission at high density currents. The p-n transition, parallel to the base, is oriented along the (111) plane and the lateral mirror faces are created by cleaving the crystals along the (110) planes. The threshold current densities of coherent emission and the power of light produced are of the same order as those of diodes with a Fabry-Pérot type resonator. Stimulated emission in such diodes begins at currents considerably lower than threshold currents. V. Z.

**A65-36826 #**

**NEODYMIUM GLASS LASER WITH PULSE-SWITCHED Q-FACTOR [OPTICHESKII KVANTOVYI GENERATOR NA NEODIMOVOM STEKLE S IMPUL'SNYM VKLUCHENIEM DOBROTNOSTI].**

N. G. Basov, V. S. Zuev, and Iu. V. Senatskii (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

ZHETF Pis'ma v Redaktsiiu, vol. 2, July 15, 1965, p. 57, 58. In Russian.

Brief note on an electro-optical shutter used by the authors for Q-factor modulation in a neodymium glass laser, in place of a device with a rotating prism. The shutter consists of two crossed polarization prisms and a Kerr capacitor controlled by a 600-nsec pulse with a 5-nsec leading edge. The operation of a laser with this type of modulation is outlined. V. Z.

**A65-36842****CONTROLLING LASER OSCILLATION.**

Stephen E. Harris (Stanford University, Stanford, Calif.), Gail A. Massey, M. Kenneth Oshman, and Russel Targ (Sylvania Electric Products, Inc., Sylvania Electronic Systems Div., Mountain View, Calif.).

Electronics, vol. 38, Sept. 20, 1965, p. 101-105. 9 refs.

Research supported by Sylvania Electric Products, Inc.; Contract No. AF 33(615)-1938.

Description of new techniques devised to control FM and supermode laser output frequencies. These new techniques are relatively simple, but retain the original power output of the laser. The threshold control method of achieving single-frequency oscillation and the technique of interferometric control are described. The FM laser and its approach to the problem of spectral control is considered, as is modulation frequency. Output of the supermode laser, and power and control of both laser types are discussed. It is concluded that FM and supermode lasers are potentially applicable to information-carrying, spectroscopy, and holography. B.B.

# 1966

## IAA ENTRIES

**A66-10240****BARIUM TITANATE LIGHT PHASE MODULATOR.**

I. P. Kaminow (Bell Telephone Laboratories, Inc., Crawford Hill Laboratory, Holmdel, N. J.).

*Applied Physics Letters*, vol. 7, Sept. 1, 1965, p. 123-125. 11 refs.

Description of an optical phase modulator using a ferroelectric barium titanate crystal plate which was built and tested at 70 Mc. Crystals, grown by the Remek method and thus occurring in very thin platelets, were chosen to be 0.004-in.-thick and were cut into 0.110-in.-wide wafers, and the narrow edges were polished. With care a wafer could be repoled into a c domain after the processing, which included heating above 120°C. Experimentally both a higher order "donut" mode of a 0.633- $\mu$  He-Ne laser and the fundamental mode maintained their identities on passing through the wafer. Some extraneous scattered light was observed in the transmitted patterns for both modes. The measured insertion loss due to reflection, scattering, and absorption was 2 db. A 0.100-in.-diam silver electrode which was evaporated on the bottom surface of the wafer and a 0.004 x 0.100-in. strip on top is shown. Care was taken not to heat the crystal above 120°C. A 0.003-in. gold wire was attached to the strip and the crystal was bonded to a brass post with conducting silver epoxy in each case. The crystal was placed in a circuit with a bandwidth of about 30 Mc tuned to 70 Mc. Two piezoelectric resonances within the band caused scattering of the beam, detuning of the circuit, and heating and fracture of the crystals when driven near 75 or 55 Mc. The 70-Mc optical heterodyne set used in measuring the phase modulation index (peak optical phase shift) is shown. The relative amplitudes of the carrier and first sidebands were measured using either optical or i.f. calibrated attenuators with similar results. The voltage across the crystal was measured with a hf electronic voltmeter and the electro-optic coefficient was determined. M.M.

**A66-10241****COHERENT OSCILLATIONS FROM  $Tm^{3+}$ ,  $Ho^{3+}$ ,  $Yb^{3+}$  AND  $Er^{3+}$  IONS IN YTTRIUM ALUMINUM GARNET.**

L. F. Johnson, J. E. Geusic, and L. G. Van Uitert (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).

*Applied Physics Letters*, vol. 7, Sept. 1, 1965, p. 127-129. 6 refs.

Tabulated summary of the optical maser characteristics of  $Tm^{3+}$ ,  $Ho^{3+}$ ,  $Yb^{3+}$ , and  $Er^{3+}$  ions in yttrium aluminum garnet (YAG). Four lines were observed from  $Tm^{3+}$ , three at 78°K in the erbium-yttrium garnet and the fourth at room temperature in crystals containing  $Cr^{3+}$ . The presence or absence of one or more of these lines was found to be strongly dependent on trace amounts of other rare-earth impurities. Continuous oscillation was obtained in  $Tm$ ,  $Er + Tm$ ,  $Er + Ho$ ,  $Cr + Tm$ , and  $Cr + Ho$  crystals at 85°K with linear xenon, mercury, and tungsten lamps. A tungsten lamp is by far the most efficient for all five systems, illustrating the effectiveness of the IR bands of  $Tm^{3+}$ ,  $Ho^{3+}$ , and  $Er^{3+}$ . Thresholds of 47, 160, 210, 315, and 520 watts were measured for  $Er + Ho$ ,  $Cr + Tm$ ,  $Cr + Ho$ ,  $Tm$ , and  $Er + Tm$  crystals, respectively. Since a tungsten lamp emits little within the absorption bands of  $Cr^{3+}$ , the figures for  $Cr + Tm$  and  $Cr + Ho$  represent thresholds which should be obtained with straight  $Tm^{3+}$  or  $Ho^{3+}$ -doped YAG. This indicates that, for tungsten-lamp illumination, the IR bands of  $Er^{3+}$  lower the threshold for  $Ho^{3+}$  oscillation by better than a factor of four. The effect of energy transfer from  $Cr^{3+}$  is seen under xenon- and mercury-lamp pumping. The lowest pulse threshold of YAG: $Ho^{3+}$  in an FT524 xenon lamp is 44 joules. With 0.5%  $Cr^{3+}$  added, the pulse threshold is lowered by about a factor of two, and CW oscillation at 85°K is obtained at 1300 watts into an AH6 mercury lamp. The corresponding figures for  $Cr^{3+} + Tm^{3+}$  are 30 joules and 800 watts. M.M.

**A66-10243****A LASER INTERFEROMETER FOR REPETITIVELY PULSED PLASMAS.**

E. B. Hooper, Jr. and G. Bekefi (Massachusetts Institute of Technology, Dept. of Physics and Research Laboratory of Electronics, Cambridge, Mass.).

*Applied Physics Letters*, vol. 7, Sept. 1, 1965, p. 133-135. 10 refs. AEC Contract No. AT (30-1)-1842.

Description of a laser interferometer operating in the optical and near infrared for measuring phase changes as small as  $2\pi \times 10^{-3}$  rad. The interferometer, which consists of a three-mirror optical resonator, was used in measurements of the time and optical variations of a repetitively pulsed plasma. The use of a synchronous detection and of a null method for phase measurement makes this instrument more than an order of magnitude more sensitive than laser interferometers. A block diagram of the experiment is shown. Measurements made at 3.39  $\mu$  showed the response time of the laser to be less than 5  $\mu$ sec. When the laser was operated near threshold, this response time increased to as much as 500  $\mu$ sec. Analysis of the noise characteristics of the interferometer shows that a drift of the operating point of the interferometer can cause a change in the sign of the laser response to a given change in dielectric coefficient. To prevent drift, the laser and its mirrors are mounted on an invar frame. M.M.

**A66-10250 #****SPATIAL DISTRIBUTION OF THE ELECTRICAL FIELD OBTAINED BY FOCUSSED THE RADIATION OF A RUBY LASER [PROSTRANSTVENNOE RASPREDELЕНИЕ ELEKTRICHESKOGO POLIA, SOZDANNOGO PUTEM FOKUSIROVKI IZLUCHENIYA OPTICHESKOGO KVANTOVOGO GENERATORA NA RUBINE].**

T. M. Barkhudarova, G. S. Voronov, V. M. Gorbunkov, and N. B. Delone (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 49, Aug. 1965, p. 386-388. 9 refs. In Russian.

Experimental study of the spatial distribution of focussed radiation of a ruby laser, showing that the minimum cross section of such a radiation corresponds dimensionally to the distribution of diffracted light from light spots present in the original light beam as it enters the objective. The fine structure in the distribution of focussed radiation, which results from the interference of individual diffraction effects, is discussed as well as various means of enhancing the focussing and of obtaining high-voltage electrical fields. V.Z.

**A66-10262 #****NEODYMIUM GLASS LASER WITH MONOPULSE DURATION NEAR THE LIMIT [LAZER NA NEODIMOVOM STEKLE S DLITEL'NOSTIU MONOIMPUL'SA, BLIZKOI K PREDEL'NOI].**

V. I. Malyshev, A. S. Markin, V. S. Petrov, I. I. Levkoev, and A. F. Voronpe (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*ZHETF Pis'ma v Redaktsiiu*, vol. 1, June 15, 1965, p. 11-17. 7 refs. In Russian.

Description of experiments in which a compound of the pentacarbocyanine series, inserted between the neodymium rod and the mirror, was used as a photostatic substance to reduce the duration of the monopulse in a neodymium laser. The oscillograms of the ~10-nsec monopulse achieved in the experiments are reproduced. Reduction of the effective length of the cavity and increasing the initial inversion population of the metastable level are other suggested means for further reducing the monopulse duration. V.Z.

**A66-10263 #****DETECTION OF A FAST PHOTOIONIZATION AUREOLE AND A CLOUD OF CONCENTRATED LONG-LIVED IONIZATION FROM THE SPARK SHOCK WAVE IN A LASER BEAM [OBNARUZHENIE BYSTROGO OREOLA FOTOIONIZATSII I OBLAKA KONTSENTRIROVANNOI DOLGOZHIVUSHCHEI IONIZATSII OT UDARNOI VOLNY ISKRY V LUCHE LAZERA].**

G. A. Askar'ian, M. S. Rabinovich, M. M. Savchenko, and A. D. Smirnova (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

ZHETF Pis'ma v Redaktsiiu, vol. 1, June 15, 1965, p. 18-23. In Russian.

Preliminary report on a photon-induced ionization aureole observed in front of the shock wave of a regular ruby laser with a Q-factor modulated by prism rotation. The aureole is investigated with microwave radiation, focusing the optical system so that both transmitted and reflected radiations can be measured. A protracted lifetime (attaining hundreds of microseconds) of the aureole plasma is revealed and the rate of formation of the ionization aureole is determined. Illustrative oscillograms are included. V. Z.

#### A66-10265 #

EFFECT OF A FOCUSED RUBY LASER BEAM ON A RUBY [DEISTVIE SFOKUSIROVANNOGO PUCHKA RUBINOVOGO OK NA RUBIN].

T. P. Belikova and E. A. Sviridenkov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

ZHETF Pis'ma v Redaktsiiu, vol. 1, June 15, 1965, p. 37-40. In Russian.

Investigation of the destructive effect in a cubical 0.8-cm ruby crystal of a focused beam from a ruby laser with  $\sim 10^7$ -watt pulse. The destruction arising along the line of the beam axis has the appearance of a chain of annular microcleavages with localized formations in their centers, and is accompanied by an intense flash with a continuous spectrum. No destruction but luminescence comprising two lines with maxima at  $\sim 630$  and  $450 \text{ m}\mu$  takes place at lower powers ( $\sim 10^6 \text{ m}\mu$ ); both effects were nonexistent in a ruby sample cooled down to  $77^\circ\text{K}$ . Possible theoretical explanations of the destructive effects are briefly discussed. V. Z.

#### A66-10324

ON A RUBY LASER EXHIBITING REGULAR SPIKES.

V. Daneu, C. A. Sacchi, and O. Svelto (Milano, Politecnico, Istituto di Fisica, Milan, Italy).

Nuovo Cimento, vol. 36, Apr. 1, 1965, p. 1042-1044. 12 refs. Research supported by the Consiglio Nazionale delle Ricerche.

Observation of regular spikes in the output of a ruby laser in a resonant cavity made up of two spherical mirrors. A  $90^\circ$ , 6.4-mm diam, 3-in. long 0.04%  $\text{Cr}^{3+}$  concentration ruby rod was placed at the center of a GE FT 524 spiral flash tube, and the system could work in a reproducible way with a repetition rate of about one shot every 20 sec. The mirrors had radii of curvature of either 27 cm or 54 cm. It is concluded that the laser oscillates at the same time in a great number of modes, and when the output is regular these various modes can subsist in the cavity without strong competition. When the output is irregular, a stronger interaction between these frequencies occurs, as is proven by the stronger mixed signal, and this probably causes the frequency outputs to switch occasionally from one value to another. F. R. L.

#### A66-10328

INTERACTION OF FOCUSED LASER RADIATION WITH A BEAM OF CHARGED PARTICLES.

G. Toraldo di Francia (Firenze, Università, Istituto di Fisica Superiore, Florence, Italy).

Nuovo Cimento, vol. 37, June 16, 1965, p. 1553-1560. 5 refs.

Study of the possibility of using a focused laser as an accelerating cavity for a cyclic accelerator. A charged particle is assumed to be shot through the focal region of a high-intensity laser beam concentrated by a lens. It is shown that, to a first approximation, no net acceleration is experienced by the particle, no matter what amplitude distribution may be produced on the lens pupil. To the same approximation, no bunching is obtained if a beam of charged particles is shot through the focal region. (Author)

#### A66-10329

POWER OVERSHOOT OF A  $6328 \text{ \AA}$  GAS LASER.

F. Barocchi, P. Burlamacchi (Consiglio Nazionale delle Ricerche, Centro Microonde, Florence, Italy), M. Mancini, and G. Toraldo di Francia (Firenze, Università, Istituto di Fisica Superiore, Florence, Italy).

Nuovo Cimento, vol. 37, June 16, 1965, p. 1810, 1811. 7 refs.

Experimental investigation of the behavior of the initial transient of a near confocal He-Ne laser, working at  $6328 \text{ \AA}$  on a pulsed discharge basis. An example of the peak power transients of the emitted light observed under the experimental conditions is shown together with the peak and stationary values of output power vs rf voltage. The stationary power reaches a maximum and then diminishes, while the peak power continuously increases in the range investigated. The IR laser output at  $1.1523 \mu$ , obtained with the same modulated discharge, by simply changing the cavity mirrors, is shown for comparison. No initial peak appears in this case, although the well-known afterglow is visible. The width of the transient peak in the visible laser remains fairly constant while the discharge power is varied at about  $50 \mu\text{sec}$  in the case considered. It is noted that the presence of the initial peak in the visible transition may be interpreted by assuming that the time necessary for creating a population inversion in the He transition is shorter than the time required for Ne to be populated. The faster decay time of He ( $2^1\text{S}$ ) with respect to He ( $2^3\text{S}$ ) may explain why the afterglow does not occur in the visible transition. M. M.

#### A66-10337

COHERENCE PROPERTIES OF A LASER BEAM.

M. Bertolotti, B. Daino (Fondazione U. Bordon, Istituto Superiore P. T., Rome, Italy), F. Gori, and D. Sette (Roma, Università, Istituto di Fisica, Rome, Italy).

Nuovo Cimento, vol. 38, Aug. 16, 1965, p. 1505-1514. 8 refs. Research supported by the Consiglio Nazionale delle Ricerche.

Investigation of the coherence properties of a laser in the case of superimposed modes, both theoretically and by means of simple interference experiments. The degree of coherence of a laser beam can be found from an examination of the interference pattern produced when the beam traverses through two holes in a screen. Measurements were performed on the spatial coherence of various helium-neon lasers emitting in the visible region at  $6328 \text{ \AA}$ , which utilized a cavity of the external concave mirror type; single-mode and compound-mode measurements were made. An examination of the phenomena of Young hole interference indicated that (1) when there is only one mode, the degree of coherence is unitary; the same is true where several axial modes are present, and (2) in the case of superposition of transverse modes the degree of coherence may have any value from zero to one depending on which pair of points are examined in the cross section of the beam. D. P. F.

#### A66-10347

MODE LOCKING BEHAVIOR OF GAS LASERS IN LONG CAVITIES.

R. E. McClure (Sperry Rand Corp., Sperry Gyroscope Co., Great Neck, N. Y.).

Applied Physics Letters, vol. 7, Sept. 15, 1965, p. 148-150.

Description of the observed dependence of self-locked laser operation on cavity length and on the position of the laser medium in the cavity. It was found that pulsed output can occur at a repetition rate which is a multiple of the usually observed  $c/2L$  frequency. Over a certain range of cavity lengths, the pulsing rate could be changed from two to three times  $c/2L$  by relocation of the laser medium. Under conditions of multiple-rate pulsing the laser spectrum, as observed with an optical scanning interferometer, displayed the corresponding multiple of  $c/2L$  frequency spacing between oscillating modes. The laser was then effectively not oscillating at all the resonant frequencies usually available within the above-threshold frequency range. R. A. F.

#### A66-10348

IDENTIFICATION OF LASER TRANSITIONS IN ELECTRON-BEAM-PUMPED GaAs.

D. A. Cusano (General Electric Co., Research Laboratory, Schenectady, N. Y.).

*Applied Physics Letters*, vol. 7, Sept. 15, 1965, p. 151, 152. 13 refs.

Evidence that laser transitions in electron-bombarded n- or p-type GaAs are impurity-dominated and of three types, depending primarily on the concentration of shallow donors and acceptors. The laser transitions observed in bulk gallium arsenide containing  $\sim 10^{16} \text{ cm}^{-3}$  of n-type dopant can be classified as (1) free-donor electron, (2) free electron-acceptor, and (3) donor-acceptor. The pumping step under electron bombardment is free hole-free electron, followed by sufficient thermalization of the hot carriers. R. A. F.

#### A66-10350

##### ELECTRON-BEAM PUMPING OF NOBLE-GAS ION LASERS.

J. M. Hammer and C. P. Wen (Radio Corporation of America, RCA Laboratories, Princeton, N. J.).

*Applied Physics Letters*, vol. 7, Sept. 15, 1965, p. 159-161. 5 refs.

Description and discussion of an electron-beam laser. Voltage, beam-current, and pressure behavior of several  $\text{Ar}^+$  laser lines are plotted. A schematic diagram of the laser is included.

R. A. F.

#### A66-10352

##### LASER ACTION IN NEODYMIUM-DOPED GLASS PRODUCED THROUGH ENERGY TRANSFER.

N. T. Melamed, C. Hirayama, and E. K. Davis (Westinghouse Electric Corp., Research Laboratories, Pittsburgh, Pa.).

*Applied Physics Letters*, vol. 7, Sept. 15, 1965, p. 170-172. 8 refs.

Evidence of a substantial increase in the efficiency of  $\text{Nd}^{3+}$  laser oscillations in glass resulting from sensitization. The enhancement was obtained in pulsed operation. The transfer time was short enough ( $< 200 \mu\text{sec}$ ) and the contribution of the sensitizer great enough that the  $\text{Nd}^{3+}$  could be made to oscillate by pumping only the sensitizer under pulsed conditions - i. e., to use the transfer of energy from sensitizer to activator as the sole means for pumping the  $\text{Nd}^{3+}$ .

R. A. F.

#### A66-10353

##### OBSERVATION OF A SUPERRADIANT SELF-TERMINATING GREEN LASER TRANSITION IN NEON.

Donald A. Leonard, Richard A. Neal, and Edward T. Gerry (Avco Corp., Avco-Everett Research Laboratory, Everett, Mass.).

*Applied Physics Letters*, vol. 7, Sept. 15, 1965, p. 175.

Observation - for what is believed to be the first time - of laser action at  $5401 \text{ \AA}$  in a pure neon pulsed high-voltage discharge. The discharge was produced in a "cross-field" device similar to that used by Leonard to achieve saturation of the second positive molecular nitrogen laser transition. At a neon pressure of 30 torr, with a plane mirror at one end of the discharge channel, a superradiant green laser pulse was observed. The pulse was observed to have a duration of 5 nsec and a peak power of  $\sim 1 \text{ kw}$ . Spectra of the laser beam showed no radiation between 3700 and  $8400 \text{ \AA}$  except for the single line at  $5401 \text{ \AA}$ .

R. A. F.

#### A66-10368

##### INTERFERENCE EFFECTS AT THIN TRANSPARENT GLASS FIBERS EXPOSED TO COHERENT LIGHT [INTERFERENZERSCHWEINUNGEN AN DÜNNEN DURCHSICHTIGEN GLASFÄDEN BEI KOHÄRENTEN BELEUCHTUNG].

Josef Gebhart and Siegfried Schmidt (Battelle - Institut, Frankfurt am Main, West Germany).

*Zeitschrift für angewandte Physik*, vol. 19, no. 2, 1965, p. 141-143. In German.

Investigation of interference effects at thin cylindrical glass fibers of diameters between 2 and  $45 \mu$  exposed to parallel beams of light ( $\lambda = 6320 \text{ \AA}$ ) emitted by a He-Ne laser. The interference field built up by the combination of reflection, refraction, and diffraction phenomena is examined. A formula for the angular distances of the interference minima is derived which is in quantitative agreement with observation.

V. P.

#### A66-10369

##### DESIGN OF GaAs INJECTION LASERS FOR PROLONGED OPERATION AT THE TEMPERATURE OF LIQUID $\text{N}_2$ [DER AUFBAU VON GaAs-INJEKTIONSLASERN FÜR DEN KONTINUIERLICHEN BETRIEB BEI DER TEMPERATUR DES FLÜSSIGEN $\text{N}_2$ ].

Helmut Salow and Klaus-Werner Benz (Deutsche Bundespost, Fernmeldetechnisches Zentralamt, Forschungs Institut, Darmstadt, West Germany).

*Zeitschrift für angewandte Physik*, vol. 19, no. 3, 1965, p. 157-161. 13 refs. In German.

Discussion of the conditions required for prolonged operation of GaAs injection laser, considering the strong temperature dependence of the laser threshold. Fluctuations in the refraction factor of GaAs materials are proved and are found to result in optical inhomogeneity that limits the length and width of the diodes. Properly shaped and well cooled laser diodes are found to produce at  $63^\circ\text{K}$  a maximum of 190 mw radiation in a single direction, with a coherent light contribution of about 85%.

V. Z.

#### A66-10448 #

##### ATOMIC BEAM LASERS [O LAZERAKH NA ATOMNYKH PUCHKAKH] N. G. Basov and V. S. Letokhov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*ZHETF Pis'ma v Redaktsiiu*, vol. 2, July 1, 1965, p. 6-9. 7 refs. In Russian.

Indication of the uses of atomic beams in lasers based on literature data. The improvement of the resolution of spectroscopes and frequency stability of lasers by the reduction of the width of the spectral line of the crystal with the aid of an atomic beam parallel to the resonator wave front is noted as one of the merits of atomic beam lasers. The technique of generating atomic beams in lasers, particularly for the population inversion in levels of optical transition, is briefly described.

V. Z.

#### A66-10450 #

##### LASER WITH A DIFFRACTION LIMITED RADIATION PATTERN [OPTICHESKII GENERATOR S DIFRAKSIONNOI SHRINOI DIAGRAMMY IZLUCHENIYA].

A. L. Mikaelian, A. V. Korovitsyn, and L. V. Naumova.

*ZHETF Pis'ma v Redaktsiiu*, vol. 2, July 1, 1965, p. 37-41. In Russian.

Description of a laser resonator with a configuration yielding very small Fresnel numbers. The resonator is developed to improve the laser radiation pattern through generation on a single low  $\text{TEM}_{00q}$  free of other types of oscillations. The relationship between the resonator length and the laser power output and the homogeneity of oscillations produced is investigated experimentally in a helium-neon laser. The results indicate that a homogeneous generation and a narrow radiation pattern unaffected by diffraction can be achieved by this technique.

V. Z.

#### A66-10446 #

##### BREAKDOWN AND HEATING OF GASES UNDER THE INFLUENCE OF A LASER BEAM [PROBOI I NAGREVANIE GAZOV POD DEISTVIEM LAZERNOGO LUCHA].

Iu. P. Raizer.

*Uspekhi Fizicheskikh Nauk*, vol. 87, Sept. 1965, p. 29-64. 61 refs. In Russian.

Review of current knowledge concerning the phenomenon of "laser spark." The breakdown of a gas in the presence of a high-intensity laser beam is described, along with the accompanying absorption of the laser radiation and heating of the gas. Several aspects of the "laser spark" phenomenon are illustrated with experimental data and subjected to theoretical analysis. Subjects treated included the multiquantum photoelectric effect, measurement of threshold parameters, cascade ionization, mechanisms for breakdown and radiation, and the buildup of electron energy in the radiation field.

R. A. F.

#### A66-10704 #

##### INVESTIGATION OF A HIGH-FREQUENCY DISCHARGE IN A HELIUM-NEON LASER [ISSLEDOVANIYE VYSOKOCHASTOTNOGO RAZRIADA V NEON-GELEIOM KVANTOVOM GENERATORE].

## A66-10718

N. I. Krindach, I. A. Silin-Bekchurin, L. N. Tunitskii, and E. M. Cherkasov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). *Zhurnal Tekhnicheskoi Fiziki*, vol. 35, Sept. 1965, p. 1678-1684. 10 refs. In Russian.

Development of a method for determining current and voltage distribution over the length of a hf discharge. It is shown that the hf discharge is stabilized by the capacitive reactance of the discharge tube, so that the stabilizing resistance is different at each point along the length of the discharge tube, and the current varies along the discharge length. The change in current with discharge length is a factor inhibiting effective use of the entire discharge length in a laser.

V. P.

## A66-10718 #

FLUORESCENCE AND LASER ACTION IN  $\text{CaF}_2:\text{Dy}^{2+}$  CRYSTALS EXCITED BY A RUBY LASER [LUMINESCENTSIYA I GENERATSIIYA KRISTALLOV  $\text{CaF}_2:\text{Dy}^{2+}$  PRI VOZBUZHDENII RUBINOVYM LAZEROM].

E. M. Zolotov, A. M. Prokhorov, and G. P. Shipulo (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 49, Sept. 1965, p. 720-723. In Russian.

Results of an experimental study of the effect of ruby laser radiation on the fluorescence and laser action in  $\text{CaF}_2:\text{Dy}^{2+}$  crystals with a total  $\text{Dy}^{2+}$  and  $\text{Dy}^{3+}$  concentration of about 0.03%. The temperature dependence of the lifetime of  $\text{Dy}^{2+}$  ions on the luminescence level is determined. The temperature dependence of the generation threshold of  $\text{CaF}_2:\text{Dy}^{2+}$  crystals is investigated and giant  $\sim 30$ -nsec laser pulses are obtained at  $2.36 \mu$ .

V. Z.

## A66-10724 #

NONLINEAR INTERACTION OF OSCILLATIONS OF DIFFERENT TYPES IN A LASER [NELINEINOE VZAIMODEISTVIE TIPOV KOLEBANIY V OPTICHESKOM KVANTOVOM GENERATORE].

N. G. Basov, V. N. Morozov, and A. N. Oraevskii (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 49, Sept. 1965, p. 895-904. 22 refs. In Russian.

Discussion of solid-crystal laser having two types of oscillation within the radiation bandwidth. It is shown (1) that the interaction of oscillations of two types can be described by velocity equations and laser stationary operation is unaffected when the oscillations are sufficiently apart in the band, and (2) that the operation may become unstable, and persistent radiative power fluctuations may develop when the oscillation modes differ inconsiderably.

V. Z.

## A66-10726 #

PERFORMANCE OF A GAS LASER WITH ANNULAR RESONATOR [O RABOTE GAZOVOGO LAZERA S KOL'TSEVYM REZONATOROM].

I. L. Bershtein and Iu. I. Zaitsev (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorki, USSR). *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 49, Sept. 1965, p. 953-959. 6 refs. In Russian.

Investigation of the phase relations of longitudinal modes in a gas laser with annular resonator. A method for determining these relations is developed, assuming a maximally "leveled" intensity distribution of the light-wave electrical field along the crystal. The results of calculations are verified by experimental measurements of the depth of photo-current modulation caused by frequency splitting of waves generated by the system. A three-mirror system was used in the  $0.63 \mu$ -wavelength experiments. The effect of small changes in the resonator length on photo-current is also discussed.

V. Z.

## A66-10778 #

INDUCED TRAVELING-WAVE EMISSION [INDUTSIROVANNOE IZLUCHENIE NA BEGUSHCHIKH VOLNAKH].

B. L. Zhelnov, A. P. Kazantsev, and V. S. Smirnov (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Institut Fiziki Poluprovodnikov, Novosibirsk, USSR).

*Fizika Tverdogo Tela*, vol. 7, Sept. 1965, p. 2816-2820. 8 refs. In Russian.

Discussion of the emission of a traveling-wave laser for the case in which the radiation field is composed of two superposed

traveling waves of arbitrary amplitude. An analysis of the generation modes of traveling-wave laser near the generation threshold shows that the following three modes are possible: (1) a strongly unstable standing-wave mode, (2) a weakly unstable "slow" traveling-wave mode, and (3) a highly stable traveling-wave mode of the form  $\exp i(\omega t - kx)$ . The slow traveling-wave mode is shown to become stable with increasing energy.

V. P.

## A66-10849

INTERFEROMETER FOR AERODYNAMIC AND HEAT TRANSFER MEASUREMENTS.

R. J. Goldstein (Minnesota, University, Dept. of Mechanical Engineering, Heat Transfer Laboratory, Minneapolis, Minn.). *Review of Scientific Instruments*, vol. 36, Oct. 1965, p. 1408-1410.

An interferometer for use in aerodynamic and heat transfer studies has been designed and tested. As in a Mach-Zehnder interferometer, the light beam is large in cross section (to permit a large field of view in the test apparatus) and traverses the test section only once. Using a continuous wave laser as a source, the light beam is split and eventually recombined when small in cross-sectional area. This permits all optical components, other than two paraboloidal mirrors, to be much smaller than the field of view in the test section. The new design results not only in a less expensive unit, since most of the components are small, but also one that is much simpler to adjust than a conventional Mach-Zehnder interferometer.

(Author)

## A66-10855

COLD CATHODES FOR POSSIBLE USE IN  $6328 \text{ \AA}$  SINGLE MODE He-Ne GAS LASERS.

U. Hochuli and P. Haldemann (Maryland, University, College Park, Md.).

*Review of Scientific Instruments*, vol. 36, Oct. 1965, p. 1493, 1494. ARPA-Navy-supported research.

Properly dimensioned aluminum cold cathodes promise single mode  $6328 \text{ \AA}$  He-Ne gas laser lifetimes exceeding 3000 h with total gas volumes of only  $50 \text{ cm}^3$ . These cathodes are simple, rugged, and require only about 0.5 W for an emission current of 5 mA dc. Beryllium cold cathodes may be even better but more time is needed for their evaluation.

(Author)

## A66-10856

MEASUREMENT OF LOW ELECTRON DENSITY IN PLASMAS USING LASER INTERFEROMETRY.

Herbert Malamud (Sperry Rand Corp., Sperry Gyroscope Co., Radiation Div., Great Neck, N.Y.).

*Review of Scientific Instruments*, vol. 36, Oct. 1965, p. 1507, 1508.

Description of a system expected to be several orders of magnitude more sensitive than other gas laser interferometers used for plasma density measurement. Its principle of operation depends on the simultaneous use of two different cavity oscillation modes such that the plasma is caused to affect only one of them, so as to change its oscillation frequency. The frequency difference between the modes then gives the desired information.

F. R. L.

## A66-10895

THERMAL PROBLEMS OF THE INJECTION LASER.

R. W. Keyes (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N.Y.).

*IBM Journal of Research and Development*, vol. 9, July 1965, p. 303-314. 6 refs.

Description of solutions to certain idealized heat flow problems which are intended to approximate the flow of heat from a junction into an adjoining body of solid material. Heat is produced during the operation of an injection laser. The thermal conduction problems associated with the flow of the heat away from the junction region are solved and the temperature increase of the junction is calculated for several simple model cases. The results are applied to the calculation of thermal limitations on the performance of gallium arsenide lasers.

M. F.

**A66-10897****TWO-DIMENSIONAL LASER DEFLECTION USING FOURIER OPTICS.**

H. J. Zweig (International Business Machines Corp., Systems Development Div., Optics Dept., San José, Calif.).  
IBM Journal of Research and Development, vol. 9, July 1965, p. 333-335. 6 refs.

Examination of the feasibility of a method of diffracting the collimated monochromatic light of a laser by means of the diffraction spectrum of crossed objects having variable frequency, periodic amplitude or phase. By such means it is possible to move an intense light over a two-dimensional field. A possible application of this principle would be in read only computer stores. The scheme is described in detail. Its limitations and tradeoffs are examined. An appendix is devoted to the derivation of light distribution in the Fraunhofer plane.

M. F.

**A66-10954****QUANTUM RADIO FREQUENCY PHYSICS.**

L. D. Stepin (Kharkov State University, Ukrainian SSR).  
 Edited by H. H. Stroke.  
 (Translation of Kurs Lektsii po Kvantovoi Radiofizike. Kharkov, 1963).  
 Cambridge, Mass., M. I. T. Press, 1965. 227 p.  
 \$6.00.

The contents of this book offer material which was originally a series of university lectures for students not specializing in quantum radio frequency physics. The main purpose was to familiarize the student with the physical concepts and some of the theoretical problems which form the foundation of quantum radio frequency physics. The reader is expected to be familiar with quantum mechanics, electronics, and superhigh-frequency physics only at an introductory level. The phenomena of electron and nuclear magnetic resonance and the methods used in their observation are discussed, and the operation of two- and three-level masers is described. Finally, radio frequency spectroscopy with gases and the operation of a molecular oscillator using a beam of ammonia molecules is considered.

B. B.

**A66-10966****PROPOSED FREQUENCY STABILIZATION OF THE FM LASER.**

S. E. Harris (Stanford University, Dept. of Electrical Engineering, Stanford, Calif.), M. Kenneth Oshman, B. J. McMurtry, and E. O. Ammann (Sylvania Electric Products, Inc., Sylvania Electronic Systems Div., Electronic Defense Laboratories, Mountain View, Calif.).

Applied Physics Letters, vol. 7, Oct. 1, 1965, p. 185-187. 7 refs.  
 Research supported by the Sylvania Independent Research and Development Program.

Description of a novel and sensitive technique for stabilizing the center frequency (or "carrier") of an FM laser with respect to the center of the atomic gain profile. The existence of the frequency discriminant is established. The stabilization technique described was proposed by Harris and Oshman and utilizes the small distortion which is always present in FM laser oscillation. Under proper conditions of FM laser oscillation, this distortion appears as small residual beats at harmonics of the driving frequency of the internal phase perturbation when the FM laser output is detected by a phototube. Of importance is the fact that the amplitudes of the odd harmonic beats are extremely sensitive to the position of the center frequency of the FM oscillation with respect to the center of the atomic line, while the amplitudes of the even harmonic beats are nearly independent of this position. In addition, the phase of the beat at odd harmonics changes abruptly as the center of the FM oscillation moves from one side of the atomic line center to the other. The FM laser, when used in conjunction with the supermode technique and the stabilization technique described, may make possible the concentration of large amounts of optical power into a stabilized and nearly single-frequency oscillation.

M. F.

**A66-10967****RING DISCHARGE EXCITATION OF GAS ION LASERS.**

W. E. Bell (Spectra-Physics, Inc., Mountain View, Calif.).  
Applied Physics Letters, vol. 7, Oct. 1, 1965, p. 190, 191. 8 refs.

Method for exciting the plasma in a ring or toroidal discharge used as a means of driving a high-current density electrodeless arc to excite gas ion laser transitions. The following properties seem to fit the known data: (1) The total voltage drop of the arc ring is of the order of the ionization potential of the gas; (2) the voltage drop is relatively insensitive to the ring circumference; (3) the arc takes additional power by increasing its cross-sectional area. It is said to be the first time that a ring discharge has been used to excite gas laser oscillation, and the ease with which circulating currents of the order of hundreds of amperes can be generated without cathodes or anodes, cataphoresis of mixtures, or gas pumping phenomena, should make the technique useful for the excitation of many gases, either noble or reactive, as ion lasers.

M. F.

**A66-10971****LASER-ACTION THRESHOLD IN ELECTRON-BEAM EXCITED GALLIUM ARSENIDE.**

Claude A. Klein (Raytheon Co., Research Div., Waltham, Mass.).  
Applied Physics Letters, vol. 7, Oct. 1, 1965, p. 200-202. 10 refs.

Evaluation of the effect of doping on the threshold behavior at very low temperatures, investigation of the threshold dependence on temperature for both p- and n-type material in ideal configurations, and comparison with recorded observations on electron-beam pumped GaAs lasers. A rough assessment of the temperature dependence may be derived from the behavior of the quasi-Fermi level under excitation conditions such that the equilibrium concentration of trapped holes remains at its 0°K level. Though quantitative comparisons may not be too meaningful, the model appears consistent with Cusano's result (0.25 amp/cm<sup>2</sup> for 25-keV electrons), and suggests that, near room temperature, it should be easier to reach threshold using more heavily compensated n-type units.

M. F.

**A66-10972****UV AND VISIBLE LASER OSCILLATIONS IN FLUORINE, PHOSPHORUS, AND CHLORINE.**

P. K. Cheo and H. G. Cooper (Bell Telephone Laboratories, Inc., Whippany, N. J.).

Applied Physics Letters, vol. 7, Oct. 1, 1965, p. 202-204. 8 refs.

Observation of 30 laser oscillations, in the wavelength range 2600 to 6700 Å, from singly and multiply ionized fluorine, phosphorus, and chlorine atoms in pulsed Cl<sub>2</sub>, PF<sub>5</sub>, and SF<sub>6</sub> gas discharges and a brief description of the emission characteristics of the line (6043 Å from P II) with the lowest current threshold. Among the three elements studied, chlorine yielded the largest number of laser oscillations. The higher threshold currents and the shorter pulsewidth in the fluorine ion laser are attributed partly to the higher-lying energy levels of the laser transitions in the fluorine ion and partly to a lower relative abundance of the fluorine ion produced in these gas discharges.

M. F.

**A66-11007 #****GENERATION OF SHARPLY DIRECTIONAL COHERENT RADIATION [O GENERATSII OSTRONAPRAVLENNOGO KOGERENTNOGO IZLUCHENIIA].**

E. M. Belenov and V. S. Letokhov.

Optika i Spektroskopiia, vol. 19, Sept. 1965, p. 465-467. In Russian.

Two methods for generating narrow-beam coherent radiation with a group of linked lasers. One method is based on interference in the far field of the coherent beams of several synchronized lasers; the other, on coherent beams originating from the multimirrored resonator of a single laser.

R. A. F.

**A66-11042 #****PULSE CIRCUITS AS POWER SOURCES FOR SEMICONDUCTOR LASERS [IMPUL'SNYYE SKHEMY DLIYA PITANIYA OPTICHESKIKH POLUPROVODNIKOVYKH GENERATOROV].**

B. D. Kopylovskii and V. S. Ivanov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Priboi i Tekhnika Eksperimenta, vol. 10, July-Aug. 1965, p. 145-148. In Russian.

## A66-11045

Description of a small-size, transistorized, semiconductor-based pulse generator which can be used for laser excitation. The generator uses Soviet-made P602 triodes and produces currents to 30 amp. The basic circuit of the generator, the shape of its pulses, and the characteristics of the triode are discussed and are shown in diagrams. V. Z.

### A66-11045 #

INVESTIGATION OF THE OPTICAL PROPERTIES OF CRYSTALS WITH THE AID OF A GAS LASER [ISSLEDOVANIYE OPTICHESKIKH SVOISTV KRISTALLOV PRI POMOSHCHI GAZOVOGO O. K. G.]. V. P. Chebotayev and V. N. Lisitsin (Akademiya Nauk SSSR, Sibirskoe Otdelenie, Institut Radiofiziki i Elektroniki, Novosibirsk, USSR).

*Prilozheniya k Tekhnika Eksperimenta*, vol. 10, July-Aug. 1965, p. 178, 179. In Russian.

Investigation of the optical properties of a ruby crystal on the basis of interference rings obtained in reflecting He-Ne laser radiation from faces of the crystal. The effectiveness of laser radiation collimated into a 0.5-to-1-mm beam in detecting local inhomogeneities in a ruby crystal is demonstrated. A block diagram of the experimental setup and representative photographs of interference rings are included. V. Z.

### A66-11058 #

THEORY OF STATIONARY EMISSION BY A HOMOGENEOUS SYSTEM IN A MULTIMODE RESONATOR. II - OPTIMUM CONDITIONS OF LASER EMISSION [TEORIYA STATSIONARNOGO VIPROMINIUVANNIA ODNORIDNOI SISTEMI V REZONATORI Z BAGAT'MA MODAMI. II - OPTIMAL'NI UMОВI LAZERNOGO VIPROMINIUVANNIA]. G. Yu. Buriakivskii and V. S. Mashkevich (Akademiya Nauk Ukrainy, Kiev, Ukrainian SSR, Institut Fiziki, Kiev, Ukrainian SSR).

*Ukrains'kii Fizichnii Zhurnal*, vol. 10, Sept. 1965, p. 991-1006. 5 refs. In Ukrainian.

Derivation of kinetic equations of optimum emission for a laser. An expression is set up for the total number of quanta emitted by special modes of a resonator in the superthreshold region for a given pumping. Pumping efficiency, optimum values of losses in special modes, and the dependence of the threshold pumping level on the concentration of active centers are determined. The transparency of the mirrors and the number of active centers are discussed as the basic parameters of emission intensity, and their optimum values are determined. V. Z.

### A66-11188 #

CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION [OPTICHESKII KVANTOVYI GENERATOR NA TELLURIDE KADMIYA S ELEKTRONNYM VOZBUZHDENIEM]. V. S. Vavilov and E. L. Nolle (Akademiya Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Akademiya Nauk SSSR, Doklady*, vol. 164, Sept. 1, 1965, p. 73, 74. 10 refs. In Russian.

Brief report on experiments in which CdTe radiation in the near infrared band was generated by electron pulses. The experimental technique is described, and curves of radiation intensity and line width vs electron current density are included. V. Z.

### A66-11189 #

ILLUMINATION OF A BUBBLE CHAMBER BY A RUBY LASER [OB OSVESHCHENII PUZYR'KOVOI KAMERY S POMOSHCH'YU OPTICHESKOGO GENERATORA NA RUBINE]. V. M. Gorbunkov, V. V. Korobkin, and A. M. Leontovich (Akademiya Nauk SSSR, Fizicheskii Institut, Moskovskii Fiziko-Tekhnicheskii Institut, Moscow, USSR).

*Akademiya Nauk SSSR, Doklady*, vol. 164, Sept. 1, 1965, p. 75-77. 8 refs. In Russian.

Experimental study of a ruby laser with a concentric resonator as the source of illumination of a bubble chamber. The experimental technique is described, and the specifications of the optical system devised are given. The illuminating system and bubble photographing process are shown in a diagram. Photographs illustrating the performance of the system are included. V. Z.

### A66-11190 #

CONTINUOUS OPERATION OF A GALLIUM ARSENIDE INJECTION LASER COOLED BY A HELIUM GAS FLOW [NEPRERYVNAIA RABOTA INZHEKTSIONNOGO OKG NA GaAs PRI OKHLAZHDENII POTOKOM GAZOBRANNOGO GELIYA]. M. N. Zargar'iants, A. A. Kiselev, O. D. Kropotova, L. N. Kurbatov, Iu. M. Liustrov, V. V. Sigriianskii, I. I. Taubkin, and I. P. Shestopalova.

*Akademiya Nauk SSSR, Doklady*, vol. 164, Sept. 1, 1965, p. 78, 79. In Russian.

Brief note on continuous laser action obtained in a gallium arsenide injection laser cooled by helium gas at  $\sim 30^\circ\text{K}$ . An optical system with an electronic converter is used for laser threshold observations from interference rings appearing on a Fabry-Pérot etalon. A line drawing of the experimental setup, with a gas cryostat as its basic component, is included. The threshold current density is given as  $360 \text{ amp/cm}^2$  at  $\sim 30^\circ\text{K}$ . V. Z.

### A66-11301

OPTICAL COMMUNICATIONS.

R. Kompfner (Bell Telephone Laboratories, Inc., Crawford Hill Laboratory, Holmdel, N.J.).

*Science*, vol. 150, Oct. 8, 1965, p. 149-155. 27 refs.

Appraisal of the many steps that have yet to be taken before practical and economically competitive optical maser communications systems can be achieved. The background of electrical communications - including microwave technology, millimeter waves, and masers and lasers - is considered. Such elements of a laser communication system as transmission media, terminals and repeaters, generators, amplifiers, modulators, and detectors are discussed, and future problems and possibilities in the medium are assessed. B. B.

### A66-11370

JUNCTION LASER.

Shigeru Iijima (Electrotechnical Laboratory, Tokyo, Japan).

*Electronics and Communications in Japan*, vol. 47, May 1964, p. 77-86. 27 refs. Translation.

Study of the general progress of semiconductor junction and ruby lasers, especially in the experimental field. The differences between junction and ruby lasers are pointed out, and fabrication of the junction laser is discussed. Previous experiments are appraised, including early work, aspects of threshold current, wavelength distribution of laser light, space distribution of laser action, and use of unique materials for the making of laser diodes. B. B.

### A66-11372

LASER BIBLIOGRAPHY. II.

K. Tomiyasu (General Electric Co., Schenectady, N.Y.).

*IEEE Journal of Quantum Electronics*, vol. QE-1, Aug. 1965, p. 199-219.

Bibliography of 561 references on all aspects of laser devices and related systems compiled during the period from January through June, 1965. The references are divided into 25 subject categories and listed chronologically. Brief annotations are added to many references. M. F.

### A66-11373

A METALLIC PLASMA TUBE FOR ION LASERS.

J. Dane Rigden (Perkin-Elmer Corp., Electro-Optical Div., Norwalk, Conn.).

*IEEE Journal of Quantum Electronics*, vol. QE-1, Aug. 1965, p. 221.

Report of the successful operation of an ion laser in which the plasma is confined by a set of cooled metal disks in place of the more conventional quartz or ceramic tube. It is considered that this type of system will eventually allow ion lasers to be run at much higher current densities than is possible with ceramic tubes. The metallic ion laser tube is described in detail. M. F.



**A66-11374****ALUMINUM NITRATE POWDER MASER.**

W. E. Hughes and W. E. Richards (Westinghouse Electric Corp., Defense and Space Center, Aerospace Div., Applied Physics Group, Baltimore, Md.).

*IEEE Journal of Quantum Electronics*, vol. QE-1, Aug. 1965, p. 221, 222.

USAF-supported research.

Description of the operation of an X-band (9.35 Gc) maser, without an external dc magnetic field, using single-crystal, polycrystalline, and powdered aluminum nitrate doped with ferric ions. The experimental facility is described, and the operational procedure outlined. It is found that net gain in excess of 25 db is achieved at 4.2 °K, with instantaneous bandwidths of 4.5 Mc and tunable bandwidths of 200 Mc.

B. B.

**A66-11375****CHARACTERISTICS OF A PULSED HIGH-PRESSURE He-Ne LASER.**

S. Kobayashi (Tokyo, University, Dept. of Applied Physics, Tokyo, Japan), H. Okamoto, and M. Kamiyama (Tokyo, University, Dept. of Electronic Engineering, Tokyo, Japan).

*IEEE Journal of Quantum Electronics*, vol. QE-1, Aug. 1965, p. 222, 223. 5 refs.

Investigation of pressure dependence of the output of a 1.153- $\mu$  He-Ne gaseous laser in a relatively high pressure range. The experimental results show: (1) CW operation stops when the total pressure is higher than 8.0 torr; (2) the enhancement effect in the afterglow becomes remarkably large as the pressure approaches the optimum value for CW laser operation, and disappears at total pressure higher than 4.0 torr; (3) high power pulse is obtained at the beginning of the excitation at rather high pressure. From the foregoing experimental results and considerations, the high power output reported by Boot et al seems to be due to the large population at the beginning of the excitation pulse rather than the afterglow period of the discharge.

M. F.

**A66-11376****CHANGE OF OPTICAL PATH LENGTH IN LASER RODS WITHIN THE PUMPING PERIOD.**

H. Welling, C. J. Bickart, and H. G. Andresen (U.S. Army, Electronics Command, Electronic Laboratories, Fort Monmouth, N.J.).

*IEEE Journal of Quantum Electronics*, vol. QE-1, Aug. 1965, p. 223, 224.

Measurement of the change of the optical pathlengths through neodymium-doped glass and ruby laser rods within the optical pumping period for a variety of pumping arrangements by means of an interferometric technique. In particular, a nonuniform change of the optical path over the cross section of the laser rods has been investigated in order to determine its influence on the beam spread characteristics of laser amplifiers. Most of the experiments have been performed with neodymium-doped glass laser rods. The investigations of the optical pathlengths should, therefore, be performed at 10,600 Å. In order to simplify the experiment a He-Ne laser with a wavelength of 6328 Å was selected for the illumination of the interferometer.

M. F.

**A66-11420 #****A MEASUREMENT METHOD OF LOSSES IN AN OPTICAL RESONATOR.**

U. W. Troitskii.

(*Radiotekhnika i Elektronika*, vol. 10, May 1965, p. 954-956.)

*Radio Engineering and Electronic Physics*, vol. 10, May 1965, p. 814-816. Translation.

[For abstract see Accession no. A65-25589 15-16]

**A66-11421 #****LASER WITH CYLINDRICAL MIRRORS.**

W. M. Klement'ev and Iu. D. Kolomnikov.

(*Radiotekhnika i Elektronika*, vol. 10, May 1965, p. 956, 957.)

*Radio Engineering and Electronic Physics*, vol. 10, May 1965, p. 816, 817. Translation.

[For abstract see Accession no. A65-25590 15-16]

**A66-11422 #****OPERATION OF A LASER ON AN MIXTURE OF He-Ne WITH DISCHARGE IN A HOLLOW CATHODE.**

V. P. Chebotayev and V. V. Pokasov.

(*Radiotekhnika i Elektronika*, vol. 10, May 1965, p. 958-960.)

*Radio Engineering and Electronic Physics*, vol. 10, May 1965, p. 817-819. Translation.

[For abstract see Accession no. A65-25591 15-16]

**A66-11443****SATURATION EFFECTS IN SECOND-HARMONIC GENERATION OF LIGHT USING UNFOCUSED LASER BEAMS.**

Charles C. Wang and George W. Racette (Philco Corp., Applied Research Laboratory, Blue Bell, Pa.).

*Journal of Applied Physics*, vol. 36, Oct. 1965, p. 3281-3284.

17 refs.

The theory of second-harmonic generation of light was examined with particular emphasis on the saturation effects occurring at high laser power levels. The nonlinear coupled Maxwell's equations were solved approximately to yield solutions of simple form. The effect of beam divergence was taken into account by averaging the solution over the entire angular spread of the laser beam. The second harmonic thus generated is seen to be proportional to the  $3/2$  power of the laser power independently of the length of the crystal in long crystals. Experimental data in good agreement with the theory are presented.

(Author)

**A66-11446****ELECTRICAL AND SPECTROGRAPHIC STUDY OF A DOUBLE-PULSED FLASHTUBE AS APPLIED TO LASER PUMPING.**

Petrus V. Avizonis and Tony Legato (USAF, Systems Command, Research and Technology Div., Weapons Laboratory, Kirtland AFB, N. Mex.).

*Journal of Applied Physics*, vol. 36, Oct. 1965, p. 3302-3307.

11 refs.

ARPA-supported research.

Excitation of ruby lasers by means of double-pumped high-intensity helical flashtubes of approximately  $10^{-4}$  sec flash duration is described. Electrical discharge parameters for double-pulse operation of the helical flashtubes were correlated experimentally and theoretically with maximum loading possible for such tubes. Time-resolved spectra of such discharges were obtained and plasma temperatures were computed from the xenon continuum. Temperatures thus computed varied from 1 to 2 eV and were correlated with peak discharge currents. The laser energy obtained from such excitation of rubies was found to be the same as that from normal (1 msec or longer) discharges having the same pump energy, but the power in the laser beam was proportionately increased with the decrease in the excitation time.

(Author)

**A66-11448****TRAVELING-WAVE RUBY LASER WITH A PASSIVE OPTICAL ISOLATOR.**

M. Hercher, M. Young, and C. B. Smoyer (Rochester University, College of Engineering and Applied Science, Institute of Optics, Rochester, N. Y.).

*Journal of Applied Physics*, vol. 36, Oct. 1965, p. 3351.

USAF-supported research.

Description of a method of obtaining traveling-wave oscillations in a ruby-laser resonator through the use of a passive optical isolator, thus eliminating the need for a Faraday rotator and an attendant magnetic field. In this method a passive optical isolator is used which introduces equal losses for both clockwise and counter-clockwise traveling waves, but feeds back part of the loss from one of the traveling waves into the direction associated with the other traveling wave.

A. B. K.

**A66-11449****INFRARED LASER INTERFEROMETRY UTILIZING QUANTUM-ELECTRONIC CROSS MODULATION.**

R. J. Freiberg, L. A. Weaver, and J. T. Verdeyen (Illinois, University, Urbana, Ill.).

*Journal of Applied Physics*, vol. 36, Oct. 1965, p. 3352.

Contract No. AF 19(682)-3307.

## A66-11451

Description of a quantum-electronic cross-modulation effect noted while monitoring infrared-laser interferometric fringes. As a result of experiments carried out using a gas laser oscillating on the  $3.39\text{-}\mu$  transition in neon, it is found that the strong coupling between laser intensity and certain nonlasing line intensities permits the rapid fringing of the coherent infrared radiation to be observed by viewing visible incoherent sidelight. A practical consequence of this effect is said to be that the laser interferometer can be operated in the far infrared while using only visible detection equipment.

A. B. K.

## A66-11451

### COMMENTS ON THE MECHANISM OF THE $337\text{-MICRON}$ CN LASER.

H. P. Broida (California, University, Santa Barbara, Calif.), K. M. Evenson (National Bureau of Standards, Boulder, Colo.), and T. T. Kikuchi (General Motors Corp., Defense Research Laboratories, Santa Barbara, Calif.).

*Journal of Applied Physics*, vol. 36, Oct. 1965, p. 3355. 11 refs.

Consideration of a suggested (by Chantry et al) laser transition at  $337\text{ }\mu$  in the vibrational state  $v = 2$  of the ground electronic state  $X^2\Sigma$  of CN from the rotational level  $K = 8$  to  $K = 7$ . A number of other possible transitions, in addition to the one suggested, are cited. Calculations of minimum formation rates of CN for maintaining population inversion are said to indicate the difficulty of obtaining the laser transition at  $337\text{ }\mu$  by the model suggested by Chantry et al.

A. B. K.

## A66-11454

### OPTICAL DEVICES AND TECHNIQUES.

D. W. Jackson (Stanford University, Stanford Electronics Laboratories, Stanford, Calif.).

IN: WESCON/65; PROCEEDINGS OF THE WESTERN ELECTRONIC SHOW AND CONVENTION, SAN FRANCISCO, CALIF., AUGUST 24-27, 1965, TECHNICAL PAPERS. PART 6 - INSTRUMENTS AND MEASUREMENT. [A66-11452 02-14]  
North Hollywood, Calif., Western Periodicals Co., 1965. 4 p. 6 refs.

Study of an attempt to resolve some of the difficulties involved in applications of lasers, and to extend their adaptability. Some of the problems studied are obtaining of the required high degree of mechanical stability, detection of movements of less than one micron, restoring a "dirty" laser beam to a diffraction-limited beam, evaluation of cube-corner retroreflectors, and noise suppression of gas lasers. It is concluded that the solutions which are found improve interferometry and radar systems, and allow successful holography.

B. B.

## A66-11455

### SURVEY OF U. S. LASER APPLICATIONS PROGRAMS.

W. H. Huntley, Jr. (Stanford University, Stanford Electronics Laboratories, Stanford, Calif.).

IN: WESCON/65; PROCEEDINGS OF THE WESTERN ELECTRONIC SHOW AND CONVENTION, SAN FRANCISCO, CALIF., AUGUST 24-27, 1965, TECHNICAL PAPERS. PART 6 - INSTRUMENTS AND MEASUREMENT. [A66-11452 02-14]  
North Hollywood, Calif., Western Periodicals Co., 1965. 5 p. 5 refs.

Outline of the development in the U.S. of laser applications, which are now the major portion of government-supported and privately financed laser activity. The governmental agencies providing major applications support are tabulated, and the larger programs in progress are illustrated with specific examples. The relationship between basic research, with resultant device improvement, and applications programs are discussed. It is concluded that early emphasis on basic devices has provided rapid improvement in laser characteristics, and that there will be a continuing challenge to engineers to apply these new devices to the many previously unsolvable problems.

B. B.

## A66-11477

### THEORY OF LASER CASCADES.

H. Haken (Stuttgart, Technische Hochschule, Institut für theoretische und angewandte Physik, Stuttgart, West Germany), R. Der Agobian, and M. Pauthier (Laboratoire Central de Télécommunications, Paris, France).

*Physical Review, 2nd Series, Section A*, vol. 140, Oct. 18, 1965, p. A437-A447. 31 refs.

Two- and three-step laser cascades have been recently detected experimentally in He-Ne mixtures and in pure neon. In the present paper a two-step cascade is treated in detail theoretically, starting with the density-matrix formulation. The corresponding equations can be simplified to rate equations under an assumption about the relative size of certain phase-memory times, which seems well justified in the present case. Because there are usually only minor differences in the results between a gaseous laser and a solid-state laser with an inhomogeneously broadened line, and because the mathematical treatment of the gas laser is more involved, the solid-state case will be treated here. The laser condition for both the lower and upper transitions is derived for the most general case, i.e., that all three levels are pumped. Finally, a special two-step cascade is treated in detail. The results are in qualitative agreement with the experimental findings, although a quantitative comparison is still impeded by the lack of an exact knowledge of some of the parameters, especially the radiative linewidth. (Author)

## A66-11692

### MODULATION TECHNIQUE IN LASER BEAM TELECOMMUNICATIONS [MODULATIONSVERFAHREN BEI DER NACHRICHTENÜBERTRAGUNG MIT LASER-STRAHLUNG].

Gerhard Blechert (Aachen, Technische Hochschule, Institut für Werkstoffe der Elektrotechnik, Aachen, West Germany).

*VDI Zeitschrift*, vol. 107, no. 29, 1965, p. 1395-1398. 18 refs. In German.

Discussion of possible future laser beam uses in telecommunication systems and of the technical problems which must be solved before these systems are realized. It is noted that the capability of carrying a multitude of signals simultaneously with a single beam is a property unique to a laser beam; this capability gives the laser a fundamental advantage over all other known communication techniques. Various laser beam modulation methods are assessed as ways of improving current technology and as grounds for further developments in this field.

V. Z.

## A66-11727

### THE ROLE OF MULTIPHOTON PROCESSES IN ESTABLISHING THE LIMITING POWER OF QUANTUM OSCILLATORS.

F. V. Bunkin and A. M. Prokhorov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, Apr. 1965, p. 1084-1086.)

*Soviet Physics - JETP*, vol. 21, Oct. 1965, p. 725, 726. Translation.

[For abstract see Accession no. A65-26025 15-26]

## A66-11728

### INTERACTION OF LASER MODES.

L. A. Ostrovskii (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorki, USSR).

(*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, Apr. 1965, p. 1087-1096.)

*Soviet Physics - JETP*, vol. 21, Oct. 1965, p. 727-732. 11 refs. Translation.

[For abstract see Accession no. A65-26026 15-16]

## A66-11820

### INTERFERENCE MIRRORS OF ALTERNATING LAYERS OF LEAD OXIDE AND CRYOLITE.

Iu. V. Naboikin and N. L. Kramarenko (Akademiia Nauk Ukrainskoi SSR, Fiziko-Tekhnicheskii Institut Nizkikh Temperatur, Kharkov, Ukrainian SSR).

(*Priboiy i Tekhnika Eksperimenta*, vol. 10, Mar.-Apr. 1965, p. 189, 190.)

*Instruments and Experimental Techniques*, Oct. 1965, p. 442, 443. Translation.

[For abstract see Accession no. A65-26039 15-16]

#### A66-11841 #

NONLINEAR PROPERTIES OF A LASER AS AN AMPLIFIER [O Nelineinykh svoistvakh lazera kak usilitelia].

T. M. Il'ina and R. V. Khokhlov (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR).

*Radiofizika*, vol. 8, no. 5, 1965, p. 899-908. 9 refs. In Russian.

Discussion of the propagation of pulse signal in a laser-type traveling-wave amplifier. It is shown that if the damping of the medium,  $\delta$ , is less than a certain threshold value, all input pulses of the system take the shape of stationary pulses, while for  $\delta$  values higher than the threshold value, all input signals will attenuate. The intensity, duration, and total energy of a stationary signal are defined by nonresonant losses and relaxation time. V. P.

#### A66-11842 #

PERIODIC AUTOMODULATION OF RADIATION AND THE POSSIBILITY OF GENERATING GIANT PULSES IN A THREE-LEVEL LASER WITH AN INHOMOGENEOUSLY EXCITED ACTIVE MEDIUM [O periodicheskoi avtomodulatsii izlucheniia i vozmozhnosti generatsii "gigantskikh" impul'sov v trekhurovnevom okk s neodnorodno podsvechennym rabochim veshchestvom].

V. I. Bespalov and E. I. Iakubovich (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

*Radiofizika*, vol. 8, no. 5, 1965, p. 909-919. In Russian.

Investigation of the effect of inhomogeneous excitation of the active medium on single-mode operation of lasers, using a laser model containing two differently excited specimens located in homogeneous regions of the resonator field. It is shown that in such systems periodic modulation of the emission can be observed and that under certain conditions giant pulses can be generated. A. B. K.

#### A66-11843 #

MASER WITH SINUSOIDAL FIELD DISTRIBUTION. IV - THE CASE OF AN ARBITRARY FIELD VALUE [Molekuliarnyi generator s sinusoidal'nym raspredeleniem polia. IV - sluchai proizvol'noi velichiny polia].

V. B. Tsaregradskii (Gor'kovskii Gosudarstvennyi Universitet, Gorki, USSR).

*Radiofizika*, vol. 8, no. 5, 1965, p. 920-923. 5 refs. In Russian.

Discussion of the oscillations of a maser with a sinusoidal distribution of the resonator field (of arbitrary amplitude) along the axis of molecular motion. A solution of the problem is obtained on the basis of an expression for the polarization of the molecular beam and the equations for stationary amplitudes and phases, previously derived by the author. The amplitude-frequency characteristics of the maser are obtained. The existence of two self-oscillating regimes of different frequency is demonstrated. A comparison with the results obtained for an arbitrary nonuniform resonator field is included. V. P.

#### A66-12003

AMPLIFICATION OF THE RADIATION OF A CO<sub>2</sub> LASER BY CARBON DIOXIDE EXCITED AT HIGH FREQUENCY [Amplification du rayonnement d'un laser a CO<sub>2</sub> par du gaz carbonique excite en haute frequence].

Robert Farrenq, Claude Meyer, Colette Rossetti, Lucien Dorbec, and Pierre Barchewitz (Paris, Université, Laboratoire d'Infrarouge, Chimie Physique, Orsay, Seine-et-Oise; Société Anonyme de Télécommunications, Laboratoire de Physique, Paris, France). *Académie des Sciences (Paris), Comptes Rendus*, vol. 261, no. 14, Oct. 4, 1965, p. 2617-2620. 7 refs. In French.

Measurement of the linear coefficient of amplification of carbon dioxide subjected to a high-frequency excitation field. The relationship of the populations of two vibration levels (00,1 and 10,00) is determined. For pure CO<sub>2</sub>, the ratio N<sub>00,1</sub> to N<sub>10,00</sub> is 1.43; for a CO<sub>2</sub> - N<sub>2</sub> mixture, the ratio is 1.55. F. R. L.

#### A66-12065 #

STIMULATED RAMAN SCATTERING [STYMULOWANE ROZPROSZENIE RAMANOWSKIE].

Roman Mierzecki (Warszawa, Uniwersytet, Instytut Fizyki, Katedra Optyki, Warsaw, Poland).

*Postepy Fizyki*, vol. 16, no. 4, 1965, p. 429-456. 39 refs. In Polish.

Survey of the current status of theoretical and experimental studies of a variant of the Raman effect encountered in the scattering of laser light in various substances. The paper is based on foreign publications published up to Aug. 1964. V. P.

#### A66-12086

ELECTROMAGNETIC THEORY OF THE INJECTION LASER.

R. F. Kazarinov, O. V. Konstantinov, V. I. Perel', and A. L. Efros (Akademiia Nauk SSSR, Fiziko-Tekhnicheskii Institut, Leningrad, USSR).

(*Fizika Tverdogo Tela*, vol. 7, May 1965, p. 1506-1516.)

*Soviet Physics - Solid State*, vol. 7, Nov. 1965, p. 1210-1217. 14 refs. Translation.

[For abstract see Accession no. A65-28487 17-16]

#### A66-12091

POSSIBILITY OF CREATING A SUPERCONDUCTING STATE IN UNDOPED SEMICONDUCTORS BY ILLUMINATION WITH A POWERFUL LASER.

A. S. Selivanenko (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(*Fizika Tverdogo Tela*, vol. 7, May 1965, p. 1567, 1568.)

*Soviet Physics - Solid State*, vol. 7, Nov. 1965, p. 1263, 1264. 6 refs. Translation.

[For abstract see Accession no. A65-28492 17-16]

#### A66-12202

TRANSMISSION CHARACTERISTICS OF FABRY-PEROT INTERFEROMETERS AND A RELATED ELECTROOPTIC MODULATOR.

V. N. Del Piano, Jr. and A. F. Quesada (Baird-Atomic, Inc., Cambridge, Mass.).

(*Optical Society of America, Annual Meeting, 49th, New York, N.Y., Oct. 7-9, 1964, Paper.*)

*Applied Optics*, vol. 4, Nov. 1965, p. 1386-1390. 7 refs.

USAF-supported research.

The effects of various types of imperfections on the transmission characteristics of a Fabry-Perot interferometer have been investigated experimentally. It was found that for light from a laser source, incident normally on an interferometer whose plates have a reflectivity in the neighborhood of 90%, angular misalignments as small as  $\lambda/25$  could seriously degrade the peak value and half-width of the transmission curve. When an electrooptic crystal was added to make the interferometer function as a modulator, a further deterioration of performance was observed. The results were compared with theoretically derived transmission functions and found to be in satisfactory agreement. (Author)

#### A66-12203

THE OPTICAL WHISPERING MODE OF POLISHED CYLINDERS AND ITS IMPLICATIONS IN LASER TECHNOLOGY.

Franklin G. Reick (International Telephone and Telegraph Corp., ITT Data and Information Systems Div., Nutley, N.J.).

*Applied Optics*, vol. 4, Nov. 1965, p. 1395-1399. 20 refs.

Experimental evidence is given showing that light tangent to an optically clear polished cylinder can refract into the cylinder and be trapped within the whispering mode. This trapped light then spirals internally at very small angles to the radius and is difficult to observe from the outside. When a step is machined on one end of the rod this light then becomes visible. It can be demonstrated

## A66-12204

that both clockwise and counterclockwise modes can exist in such a system. The implications of such an effect in the pumping of polished cylindrical lasers are discussed. (Author)

### A66-12204

#### LOSSLESS CONVERSION OF A PLANE LASER WAVE TO A PLANE WAVE OF UNIFORM IRRADIANCE.

B. Roy Frieden (Rochester, University, Institute of Optics, Rochester, N.Y.).

Applied Optics, vol. 4, Nov. 1965, p. 1400-1403. 6 refs. NASA-supported research.

Interest has recently been shown in methods of converting the plane wave from a laser in the uniphase  $TEM_{0,0}$  mode to a plane wave having (a) uniform irradiance over a required cross section, and (b) all the power of the original beam. Two methods are proposed for accomplishing these aims: one employs two plano-convex lenses; the other requires a pair of selectively aberrated lens systems. A computer program has been written which determines the aspheric, and one example is presented. The aberrations required of the second method are expressed algebraically in terms of known quantities. These aberrations could conceivably be designed into a system of spherical lenses, by use of one of the automatic lens design programs now extant. (Author)

### A66-12205

#### A STUDY OF PARTIAL COHERENCE AND ITS APPLICATION TO THE COLLIMATION OF PULSED MULTIMODE LASER RADIATION.

W. S. C. Chang and N. R. Kilcoyne (Ohio State University, Dept. of Electrical Engineering, Antenna Laboratory, Columbus, Ohio).

Applied Optics, vol. 4, Nov. 1965, p. 1404-1411. 32 refs. USAF-supported research.

Classical coherence theory as presented by Wolf with the modification proposed by Neugebauer is used to describe mathematically and experimentally the collimation and focusing of the time-averaged intensity of pulsed multimode laser radiation. Measurements of the double-slit Fraunhofer pattern and the near and far zone intensity patterns were made on two pulsed ruby lasers by both still and streak photography to examine the spatial coherence and the collimation of the beam. Our result showed that the time-averaged collimation and focusing characteristics of the beam can be treated as the superposition of noncoupled spatially coherent modes. (Author)

### A66-12206

#### STUDY OF HELIUM-NEON LASER AMPLIFICATION AT $3.39 \mu$ .

G. K. Moeller and T. K. McCubbin, Jr. (Pennsylvania State University, Dept. of Physics, University Park, Pa.).

Applied Optics, vol. 4, Nov. 1965, p. 1412-1415. USAF-supported research.

The dependence of the gain of a helium-neon laser amplifier for  $3.39\text{-}\mu$  radiation as a function of input signal power, discharge current, mixture ratio, and total gas pressure has been investigated. A display of these results in the form of plots of the contours of constant amplification on the discharge current-pressure plane for various mixture ratios shows ridges of maximum gain running in the direction of increasing current and decreasing pressure. At high helium-to-neon ratios the ridge has two peaks. The saturation of the gain with input signal has been observed for a wide range of conditions and is in agreement with the theory of White et al. (Author)

### A66-12215

#### A NOTE ON LINEAR EXTRAPOLATION OF MULTIVARIABLE FUNCTIONS BY THE MONTE CARLO METHOD.

Takao Tsuda and Hiroshi Matsumoto (Kyoto University, Dept. of Electronic Engineering, Kyoto, Japan).

Association for Computing Machinery, Journal, vol. 13, Jan. 1966, p. 143-150.

The feasibility of Monte Carlo linear extrapolation of multivariable functions is discussed. The method considered is a modified version of the Monte Carlo method for linear interpolation. An effective truncation procedure is introduced, which not only economizes the machine time to a great extent, but also serves for the purpose of variance reduction. A few examples were tested, all of which have shown that the method is promising. (Author)

### A66-12217

#### MAGNIFICATION OF SMALL RAY DEVIATIONS BY LASER RODS WITH BREWSTER-ANGLE ENDS.

James N. Bradford (U.S. Naval Research Laboratory, Washington, D.C.).

Applied Optics, vol. 4, Nov. 1965, p. 1511, 1512.

Analysis of some discrepancies in measurements on the beam-spread introduced by refractive inhomogeneities in large ruby rods. It was discovered that the discrepancy resulted from the fact that the two sets of measurements had been made with different rod geometries. The discrepancies arose from the introduction of angular magnification by the Brewster-angle geometry. A simple analysis is noted which may be helpful to those who design and evaluate laser systems in which beam divergence is critical. The average or mean magnification is found to be in substantial agreement with the discrepancies which had to be resolved. M.F.

### A66-12293

#### DIFFRACTION SYNCHRONIZATION OF LASERS.

N. G. Basov, E. M. Belenov, and V. S. Letokhov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Zhurnal Tekhnicheskoi Fiziki, vol. 35, June 1965, p. 1098-1105.) Soviet Physics - Technical Physics, vol. 10, Dec. 1965, p. 845-850. 12 refs. Translation.

[For abstract see Accession no. A65-28538 17-16]

### A66-12303

#### BREADTH OF DECAY QUANTA IN GAS LASERS.

J. A. White (National Bureau of Standards, Washington, D.C.; Maryland, University, College Park, Md.).

Optical Society of America, Journal, vol. 55, Nov. 1965, p. 1436-1442. 5 refs.

Expressions for the dependencies of the linewidths on the energies and lifetimes of states other than those directly involved in the spontaneous transitions and on the intensity of the coherent radiation, for laser oscillations near and far above threshold in the limits that the quanta of energy emitted spontaneously are either much larger or much smaller than the quanta emitted coherently. It is suggested that the fine structure might be useful for precise spectroscopic determinations of a few atomic energy level separation and natural lifetimes and for studies of broadenings arising from atomic collisions and interactions with intense radiation. M.F.

### A66-12308

#### GAIN AND BANDWIDTH NARROWING IN A REGENERATIVE He-Xe LASER AMPLIFIER.

Vern N. Smiley, Adolph L. Lewis, and David K. Forbes (U.S. Navy, Electronics Laboratory, San Diego, Calif.).

Optical Society of America, Journal, vol. 55, Nov. 1965, p. 1552, 1553.

Experimental gain and bandwidth measurements for a He-Xe regenerative laser amplifier operated at low input power levels. It was found that the bandwidth narrowed with increasing gain at low gain values but narrowed less rapidly at higher gain values. Many gain and bandwidth measurements of the amplifier were made at different gain levels. Broadening mechanisms include vibration, fluctuations in discharge intensity, and saturation. The first two mechanisms can also produce narrowing and hence along with bandwidth reading errors cause scatter in the data. Vibration is minimized by mounting the oscillator and interferometer on a massive vibration-isolated granite slab. Changes in discharge intensity and hence single-pass gain are partially reduced by using a well-regulated, constant current power supply. Saturation depends on input intensity level and gain and in addition is frequency-dependent. M.F.

### A66-12422

#### BRILLOUIN SCATTERING IN LIQUIDS.

G. Benedek and T. Greytak (Massachusetts Institute of Technology, Dept. of Physics and Center for Materials Science and Engineering, Cambridge, Mass.).

IEEE, Proceedings, vol. 53, Oct. 1965, p. 1623-1629. 12 refs. Contract No. ARPA SD-90.

The development of monochromatic, intense, and highly directional laser light sources has made it possible to measure accurately the velocity, the frequency, and the lifetimes of thermally excited hypersonic sound waves. The technique employed is to study the spectrum of the light scattered from the thermally generated sound waves in the medium. A theory is presented which demonstrates explicitly the information contained in the intensity, the spectral positions, and spectral widths of the scattered light. An experimental system is also described to measure the spectrum. Preliminary data are presented on the velocity and lifetimes of  $\sim 6$  Gc/s sound waves in water and toluene. (Author)

#### A66-12423 #

##### LASER EXCITATION OF MODES IN X-CUT QUARTZ.

M. Katzman (Electro-Optical Systems, Inc., Pasadena, Calif.), Seymour Epstein, F. Molz, W. E. Bicknell, and J. W. Strozzyk (U.S. Army, Electronics Command, Fort Monmouth, N.J.). *IEEE, Proceedings*, vol. 53, Oct. 1965, p. 1635, 1636. 6 refs.

Data to demonstrate the extent to which lasers can excite, in quartz, the elastic modes of a thick plate. Possible phenomenological energy coupling mechanisms are suggested. The experiments consisted of measuring the piezoelectric signal generated in quartz between X-face electrodes during and after the single traversal through the specimen of a one kw (average pulse power), focused and unfocused, ruby laser beam. The X dimension was such that the calculated resonant frequency for the X-extensional mode was 125 kc. The plate was found to have additional resonances at 130 and 40 kc. It is noted that among the mechanisms for coupling laser energy into elastic plate modes are optical rectification, false pyroelectricity, and electrostriction. F.R.L.

#### A66-12437

##### THE RADIOMETRIC PERFORMANCE OF A SOLID-STATE 35-Gc RECEIVER.

P. R. Jordan and H. G. Pascalar (Space-General Corp., El Monte, Calif.).

*IEEE, Proceedings*, vol. 53, Oct. 1965, p. 1655, 1656.

Description of the radiometric performance achieved with a solid-state 35-Gc superheterodyne receiver. This receiver, when used in a Dicke-type radiometer, results in an rms value of temperature fluctuation equal to  $0.2^\circ\text{K}$  for an integration time of 1 sec. The performance is comparable to that obtained to date using masers and parametric amplifiers. It is the result of employing an integral structure incorporating a balanced mixer and a broadband uhf transistor IR preamplifier. A block diagram of the receiver is shown. The total gain of the IR amplifier chain is 50 db. Successful operation is obtained with this rather low amplifier gain requirement as a result of using a tunnel-diode square-law detector. The high responsivity and low video impedance of the tunnel diode, together with the low noise figure of the postdetection (video) amplifier, effect a significant reduction in the predetection gain requirement. The postdetection amplifier consists of a hybrid-type flat pack mounted integrally with the rf portion of the square-law detector. Some details of the solid-state receiver are shown. M.M.

#### A66-12439

##### ON THE DEPENDENCE OF He-Ne LASER DISCHARGE CURRENT ON LASER ACTION.

G. Schiffner and F. Seifert (Wien, Technische Hochschule, Institut für Hochfrequenztechnik, Vienna, Austria).

*IEEE, Proceedings*, vol. 53, Oct. 1965, p. 1657, 1658.

Research supported by the Ludwig Boltzmann-Gesellschaft.

Observation that the discharge current of a dc-excited He-Ne laser depends on laser action. If the beam inside the optical resonator is interrupted, the discharge current increases. The effect is about a magnitude higher in the case of the visible than in the case of the IR line. Pulsed laser action with a frequency of about 500 cps was attained by means of a rotating chopper arranged inside the resonator. The discharge current and the intensity of laser radiation were displayed on the screen of a double-beam oscilloscope. It is suggested that the effects are observed because the upper level of the laser transition is depopulated by laser action. In noble gas discharges, the atoms are ionized by electron impact, stepwise populating higher and higher energy levels till ionization energy is reached. Therefore, the depopulation of an energy level

near the ionization edge decreases the density of Ne-ions and of electrons in the plasma. This causes a higher resistance of the discharge and a lower current. M.F.

#### A66-12441

##### A WIDE TUNING RANGE L-BAND TRAVELING-WAVE MASER.

B. J. Walker (Department of Defense, Washington, D.C.).

*IEEE, Proceedings*, vol. 53, Oct. 1965, p. 1661, 1662. 5 refs.

Description of an experimental traveling-wave maser with an exceptionally wide tuning range. Net gains in excess of 35 db have been obtained over a frequency range of 1.4 to 2.0 Gc at a bath temperature of  $4.2^\circ\text{K}$ . Noise temperature did not exceed  $17^\circ\text{K}$  over this frequency range. The slow-wave structure used in this maser is the meander-line tape structure analyzed by Butcher. Three materials were investigated for possible use in this maser:  $\text{Cr}^{3+}$ -doped  $\text{Al}_2\text{O}_3$  (ruby),  $\text{Fe}^{3+}$ -doped  $\text{TiO}_2$ , and  $\text{Cr}^{3+}$ -doped  $\text{TiO}_2$  (rutile). The resonance isolator material used in this amplifier was a gadolinium substituted yttrium iron garnet. The final amplifier consists of two 7.5-in.-long sections, folded back to back, each containing two subsections of different meander line widths. The net gain and VSWR obtained with this maser are shown. M.F.

#### A66-12442

##### GAAs OPTICALLY COUPLED TRANSISTOR WITH A LASING EMITTER.

R. F. Rutz, M. I. Nathan, A. E. Michel, and J. C. Marinace (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N.Y.).

*IEEE, Proceedings*, vol. 53, Oct. 1965, p. 1664. 5 refs.

Announcement of the operation of a GaAs optically coupled transistor structure in which the emitter is lasing and in which higher values of the collection efficiency  $\alpha$  can be obtained. The observation of high-frequency (100 to 1200 Mc) oscillation of this structure is also reported. The device was operated at  $4.2^\circ\text{K}$  using current pulses up to  $1\mu\text{sec}$  in duration. The structure has been operated as an optically bistable element and as a frequency modulator, and the details of its fabrication procedure have been described. It is a GaAs laser with a channel etched in the p region parallel to the reflecting ends. One part of the p region is forward biased and serves as the emitter and the other part is the collector. If the collector voltage  $V_c$  is displayed on a high-frequency oscilloscope, oscillations are sometimes observed near threshold. The frequency varies from unit to unit from 100 to about 1200 Mc. M.F.

#### A66-12445

##### PHASED ARRAY TYPE SCANNING OF A LASER BEAM.

A. Korpel (Zenith Radio Corp., Chicago, Ill.).

*IEEE, Proceedings*, vol. 53, Oct. 1965, p. 1666, 1667.

Description of a method of angular scanning of a laser beam which makes use of the time coherence of laser light to form a multiple beam phased array. The basic structure consists of 2 parallel mirrors, with amplitude reflectivities  $R_1$  and  $R_2$  and aperture D, separated by a distance L. A beam of laser light of diameter d enters the left mirror under an angle  $\beta$  through a hole in the mirror coating. By multiple reflections a system of parallel beams is formed, each of diameter d (neglecting diffraction) and separation  $s = 2L \sin \beta$ . In order to avoid resonant entrance conditions, care is taken that the beams do not overlap. The direction of the resultant (far-field) beam depends on the relative phase between neighboring near-field beams and can be made to vary by varying the optical path length L. It also appears possible to use a second mirror system to produce a phased array of near-field line sources from the single line generated by the first mirror. This would allow scanning in 2 dimensions. F.R.L.

#### A66-12447

##### CUTOFF OF RUBY LASER EMISSION BY PULSED IRRADIATION.

D. M. J. Compton, R. A. Cesena, J. F. Bryant, and B. L. Gehman (General Dynamics Corp., General Atomic Div., San Diego, Calif.).

*IEEE, Proceedings*, vol. 53, Oct. 1965, p. 1668, 1669. 6 refs.

Contract No. AF 33(657)-11696.

## A66-12473

Demonstration that laser output from an optically pumped ruby is temporarily quenched by a quite small dose of radiation delivered in a pulsed manner. Pulses of electrons were used to provide, through a ruby laser rod, a radiation dose that consisted of electrons and brehmsstrahlung. The dose was measured using the adiabatic temperature rise in a thermistor placed at the same position as the laser rod.

F.R.L.

## A66-12473

PHOTOELECTRON STATISTICS FOR A PHOTOMULTIPLIER LIT BY COHERENT AND NON-COHERENT LIGHT - ULTIMATE SENSITIVITY LIMIT FOR OPTICAL RECEIVERS [STATISTIQUE DES PHOTOELECTRONS D'UN PHOTOMULTIPLICATEUR ECLAIRE EN LUMIERES COHERENTE ET INCOHERENTE - LIMITE ULTIME DE SENSIBILITE DES RECEPTEURS OPTIQUES].

R. Marcy and J. Marguin (Compagnie Française Thomson-Houston, Service d'Etudes Techniques Avancées, Bagneux, France).

(Société Française des Electroniciens et des Radioélectriciens, Conférence, Jan. 6, 1965, Paper.)

L'Onde Electrique, vol. 45, Sept. 1965, p. 1102-1109. In French.

A study of the ultimate sensitivity limits for optical receivers and especially for photomultipliers. In order to measure the sensitivity limits of the 150 AVP and the 150 CVP tubes without trouble from thermal noise the receiver is cooled to the temperature of liquid nitrogen. In these circumstances when the level of the source is extremely weak the photoelectrons displaced from the photocathode appear at the output tube as discrete pulses distributed randomly in time. The counting of the number of pulses within a given time leads to a definition of the time probability for the emission of photoelectrons. This measurement has been made using successively a conventional source in the form of a tungsten lamp and a laser. In these two cases the probability law found is a Poisson law. This result shows that the limit of sensitivity for an optical receiver is the same with a conventional source as with a laser. The latter can therefore form an emitting source of an optical circuit which makes it possible to use the advantage of high coherence in the laser without being troubled by any loss of sensitivity which might have been thought inherent in the use of it.

(Author)

## A66-12577

p-n JUNCTION ELECTROLUMINESCENCE AND DIODE LASERS. Henry T. Minden (Sperry Rand Corp., Sperry Rand Research Center, Sudbury, Mass.).

IEEE Transactions on Parts, Materials, and Packaging, vol. PMP-1, Sept. 1965, p. 40-47. 41 refs.

Observation of electroluminescence in forward-biased semiconductor p-n junctions. The wavelength of the light varied with the material, and the efficiency was about 10%. Fabry-Perot diodes were observed to lase above threshold. This laser emission can be modulated simply by modulating the input current. The stimulated decay time was  $< 0.2 \mu\text{sec}$ . The additional facts that diodes have been made to amplify light, and that various cooperative and quenching effects have been observed in optically coupled chips are seen to suggest the use of diode lasers as computer elements.

R.A.F.

## A66-12602 #

DEPENDENCE OF THE POWER OUTPUT AND DURATION OF RUBY-LASER PULSES ON PUMPING [ZAVISIMOST' VYKHODNOI ENERGI I DLITEL'NOSTI GENERATSII RUBINOVOGO OKG OT NAKACHKI].

R. I. Gintoft and A. M. Sarzhvskii (Akademiia Nauk Belorusskoi SSR, Institut Fiziki, Minsk, Belorussian SSR).

Akademiia Nauk BSSR, Doklady, vol. 9, Sept. 1965, p. 578-580. In Russian.

Theoretical and experimental investigation showing that, to obtain maximum output power of a laser, there exist optimum pumping conditions. It is noted that an increase in pumping power will at a certain point decrease the output power, instead of increasing it. A mechanism explaining this change in output power and pulse duration is proposed.

V.P.

## A66-12623

MODERN OPTICS.

E. B. Brown (Perkin-Elmer Corp., Norwalk, Conn.). New York, Reinhold Publishing Corp., 1965. 645 p. \$25.

An extensive summary of essential facts about light and optical instruments and devices, including the laser and coherent light, is offered to mechanical, electrical, and chemical engineers. The complete physical background of geometrical optics is reviewed, and the various types of lens systems are covered in detail. All optical instruments are classified into a few fundamental types, and pupils and apertures are discussed on a practical level. An exposition of image orientation in systems containing mirrors and prisms is given, and a considerable mathematical development is provided in the case of the Fourier transform analysis. An effort has been made to compile a comprehensive bibliography to enable individual readers to pursue in greater depth their specific interests in particular fields.

M.M.

## A66-12627 #

NARROWING OF EMISSION BANDS OF A RUBY LASER WITH A COMPOUND RESONATOR [SUZHENIE POLOS Y IZLUCHENIIA RUBINOVOGO LAZERA SO SLOZHNYM REZONATOROM].

F. A. Korolev and S. M. Mamedzade (Moskovskii Gosudarstvennyi Universitet, Kafedra Optiki, Moscow, USSR).

Moskovskii Universitet, Vestnik, Seriya III - Fizika, Astronomiia, vol. 20, Sept.-Oct. 1965, p. 91, 92. In Russian.

Use of a multiple light filter to narrow the emission bands of a ruby laser with a multiplex resonator. The method is based on the cancellation of excessive transmission maxima from each of the two simple light filters combined to form the multiple filter.

R.A.F.

## A66-12940

POSSIBLE MATERIALS FOR SECOND HARMONIC GENERATION AND FOR LASER ACTION.

C. B. van den Berg (N. V. Ronette Piezoelectrische Industrie, Laboratorium, Marum, Groningen, Netherlands).

Physica Status Solidi, vol. 11, no. 2, 1965, p. 617-628. 33 refs.

The possibility is discussed of obtaining laser action in the group of crystals of composition  $[\text{Me(III)en}_3] \text{X}_3$  with some  $\text{Me(III)} = \text{Rh}$  and/or  $\text{Ir}$  replaced by  $\text{Cr(III)}$ ;  $\text{en} = 1, 2$  diaminoethane. The optical properties are nearly independent of the nature of X. Large crystals of fine optical quality can be grown and the group contains centrosymmetric as well as piezoelectric crystals. Apart from the above possibility a second harmonic generating device is proposed consisting of a single-crystal plate comprising alternate layers of noncentrosymmetric  $[\text{Rh}_1 - x \text{Ir}_x \text{en}_3] \text{X}_3$  and  $[\text{Rh}_1 - x - y \text{Ir}_x \text{Co}_y \text{en}_3] \text{X}_3$ . The  $\text{Co(III)}$ -ions act as SHG-active centers and the periodic array maintains coherence between the  $2\omega$ -waves. The device is not limited to a specific crystallographic direction. There is no restriction by the aperture effect for the case in which the fundamental frequency enters the device perpendicular and along a principal axis. Construction of this periodic array appears to be possible. (Author)

## A66-12975

LASER-CREATED PLASMAS [PLASMAS CREES PAR UN LASER].

P. Nelson (Commissariat à l'Energie Atomique, Paris, France).

IN: FRENCH SOCIETY OF PHYSICS, ATOMICAL COLLOQUIUM OF THE PHYSICS OF IONIZED MEDIA, 1ST, TOULOUSE, FRANCE, MAY 28, 29, 1965 [SOCIETE FRANCAISE DE PHYSIQUE, COLLOQUE NATIONAL DE PHYSIQUE DES MILIEUX IONISES, 1ST, TOULOUSE, FRANCE, MAY 28, 29, 1965]. [A66-12965 03-25]

Journal de Physique, vol. 26, Aug.-Sept. 1965, p. 476-482. 18 refs. In French.

Experimental measurements of plasma production by a laser, producing good quantitative results leading to a theoretical interpretation. When the beam of a pulsed laser is focused on a metallic target, it makes a crater and produces an intense emission of ions, electrons, and X rays of a few kev. These phenomena are produced by the absorption of light by the skin effect. The beam of a pulsed laser focused in a gas forms a sphere of very opaque ionized gas. Ionization and absorption are due to multiphoton ionization. The hydrodynamics of the ball are studied.

F.R.L.

**A66-12978**

OBSERVATIONS ON THE EFFECTS OF FOCUSSED AN INTENSE BEAM OF LIGHT IN A GAS [OBSERVATIONS DES EFFETS DE LA FOCALISATION D'UN FAISCEAU LUMINEUX INTENSE DANS UN GAZ].

C. Breton, M. Capet, V. Chalmeton, D. Nguyen Quang, and R. Papoulet (EURATOM and Commissariat à l'Énergie Atomique, Groupe de Recherches sur la Fusion, Fontenay-aux-Roses, Seine, France).

IN: FRENCH SOCIETY OF PHYSICS, NATIONAL COLLOQUIUM OF THE PHYSICS OF IONIZED MEDIA, 1ST, TOULOUSE, FRANCE, MAY 28, 29, 1965 [SOCIÉTÉ FRANÇAISE DE PHYSIQUE, COLLOQUE NATIONAL DE PHYSIQUE DES MILIEUX IONISÉS, 1ST, TOULOUSE, FRANCE, MAY 28, 29, 1965]. [A66-12965 03-25] *Journal de Physique*, vol. 26, Aug.-Sept. 1965, p. 490-493. In French.

Light-induced discharges have been studied by time-resolved spectroscopy and photography. Experiments have been performed in nitrogen at pressures between 1 and 25 atm, with a neodymium-doped glass laser (1.06  $\mu$ , 30 Mw). The emitted spectrum starting shortly before the breakdown and increasing during the laser pulse is a continuum covering the near uv and visible regions. Its shape does not depend noticeably upon the pressure or the beam intensity. (Author)

**A66-12980**

INTERACTION OF ELECTROMAGNETIC FIELDS DRIFTING WITH THE IONIZED GASES [INTERACTION DES CHAMPS ELECTROMAGNETIQUES GLISSANTS AVEC LES GAZ IONISÉS].

J. M. Rocard (Litton Industries, Inc., Beverly Hills, Calif.).

IN: FRENCH SOCIETY OF PHYSICS, NATIONAL COLLOQUIUM OF THE PHYSICS OF IONIZED MEDIA, 1ST, TOULOUSE, FRANCE, MAY 28, 29, 1965 [SOCIÉTÉ FRANÇAISE DE PHYSIQUE, COLLOQUE NATIONAL DE PHYSIQUE DES MILIEUX IONISÉS, 1ST, TOULOUSE, FRANCE, MAY 28, 29, 1965]. [A66-12965 03-25] *Journal de Physique*, vol. 26, Aug.-Sept. 1965, p. 497-504. 6 refs. In French.

Consideration of the importance of checking that the Lorentz forces used in traveling-wave accelerators have always the same direction, and that the magnetic induction is still important in spite of plasma loading. Some properties of traveling fields, due to a linear coil system fed by polyphased currents, are described briefly. In particular, the end effects, which appear as "bumps" in the profile of the magnetic induction along the accelerator axis, may cause a deceleration of the ionized gas jet. This situation, it is noted, can be avoided by a judicious configuration of the coil system. The interactions of the ionized gas with the field-producing currents can introduce some instabilities which, in turn, react on the traveling field itself. These effects are avoided when the polyphased networks are tuned in a completely symmetric manner.

M.M.

**A66-12994**

A CONSIDERATION OF THE BIOLOGICAL EFFECTS OF LASER.

Alan J. McCartney (U.S. Army, Medical Research Laboratory, Div. of Biophysics, Fort Knox, Ky.).

*Military Medicine*, vol. 130, Nov. 1965, p. 1069-1077. 39 refs.

Description of the physical properties of laser radiation, with an attempt to correlate these properties with observed biological effects. The effects are described with reference to intact animals, primate eyes, skin, and malignant tumors of animal and human origin. It is considered that within the present state of the technology, laser radiation does not represent a lethal hazard to man. It is, however, capable of inflicting severe damage on the unprotected eye, and all due safety precautions should be observed. The rapid development of laser technology ensures an increasingly important role for the laser. In medicine, preliminary reports indicate promise in the fields of cellular research, cancer therapy, and ophthalmology.

F.R.L.

**A66-12997 #**

OPTICAL DATA PROCESSING.

W. B. Wrigley (Lockheed Aircraft Corp., Lockheed-Georgia Co., Research Laboratory, Marietta, Ga.).

*Lockheed Georgia Quarterly*, vol. 2, no. 3, 1965, p. 8-13.

Speculation on the extent that optical methods may be applied to the burgeoning field of data processing. Aspects of the storage of data and its manipulation are considered, and the advantages and capabilities of holographic techniques are indicated. The phenomenon of holography is described and illustrated through the production of a 3-D hologram. Another improved application of optical data processing techniques which is described concerns pattern recognition using matched filters; the fabrication and usage of matched filters is outlined, their selectivity is illustrated, and their advantages and shortcomings are pointed out. B.B.

**A66-13002**

INTERNAL SELF-DAMAGE OF RUBY AND Nd-GLASS LASERS.

P. V. Avizonis and T. Farrington.

*Applied Physics Letters*, vol. 7, Oct. 15, 1965, p. 205, 206.

ARPA-supported research.

Summary of data on internal bubble formation and cracking in the rods of Q-switched ruby and Nd-glass lasers. The damage was determined to be strictly due to laser light. The energy damage threshold - based on the appearance of bubbles inside the laser material on the first shot of a laser rod - was measured for both types of material. Damage in Nd-glass rods was due to platinum inclusions in the glass; the mechanism of internal damage to the rubies is not known.

R.A.F.

**A66-13003**

PRESSURE-TUNED PbSe DIODE LASER.

J. M. Besson, W. Paul (Harvard University, Cambridge, Mass.),

J. F. Butler, A. R. Calawa, and R. H. Rediker (Massachusetts

Institute of Technology, Lincoln Laboratory, Lexington, Mass.).

*Applied Physics Letters*, vol. 7, Oct. 15, 1965, p. 206-208. 11 refs.

Research supported by Harvard University; Contracts No. ARPA SD-88; No. Nonr-1866(10).

Experimental observation of the shift to longer wavelengths with increasing hydrostatic pressure of the coherent and spontaneous emission from PbSe diode lasers. The position of the dominant cavity modes at each pressure is plotted vs pressure. The variation is nearly linear with a slope of  $-8.50 \times 10^{-6}$  eV/bar, which is believed to correspond to the pressure coefficient of the peak of the spontaneous emission. This value is seen to be in substantial agreement with the pressure coefficient of  $-9 \times 10^{-6}$  eV/bar of the optical absorption edge.

R.A.F.

**A66-13006**

THE POLARIZATION OF LIGHT FROM Nd<sup>3+</sup>-GLASS LASERS.

Sam Lu and T. A. Rabson (William Marsh Rice University, Houston, Tex.).

*Applied Physics Letters*, vol. 7, Oct. 15, 1965, p. 219, 220.

Grant No. NSG-6-59.

Polarization measurement, with a time resolution  $<1 \mu$ sec, of light from a glass laser doped with 2% Nd<sup>3+</sup>. The beam was split, into six identical components and an analysis made, using several polarization analyzers, a quarter-wave plate, and six photomultiplier detectors. Since no spatial variation in polarization across the cross section of the beam can be measured with this technique, the polarization reported can be considered the lower limit on the percent polarization of the light contained in any subarea of the beam's cross section. Data indicate that the polarization of the 1.06- $\mu$  light emitted by a 2% Nd<sup>3+</sup>-doped pulsed laser changes from spike to spike. The percentage of polarized light from the laser appears to increase with lower pumping energies. The measured Stokes' parameters and the percent polarization of successive output spikes are tabulated.

R.A.F.

**A66-13097**

ON THE FILAMENTS IN A TYPICAL LASER WITH PLANE PARALLEL MIRRORS.

Helmut K. V. Lotsch (Northrop Corp., Northrop Space Laboratories, Hawthorne, Calif.).

*Zeitschrift für angewandte Mathematik und Physik*, vol. 16, Sept. 25, 1965, p. 704-706. 7 refs.

Development of an expression for the intensity distribution which, in a Fabry-Pérot interferometer, in the case of a large Fresnel number, produces resonant waves. Based on the theoretical results, a model for the filament-form laser mechanism is produced for the purpose of interpreting experimental observations.

F.R.L.

**A66-13135**

## THEORY OF MAGNETIC EFFECTS IN OPTICAL MASER AMPLIFIERS AND OSCILLATORS.

C. V. Heer and R. D. Graft (Ohio State University, Dept. of Physics Columbus, Ohio).

Physical Review, 2nd Series, Section A, vol. 140, Nov. 15, 1965, p. A1088-A1104. 34 refs.

Grant No. NsG-552.

Development of a theoretical model for the behavior of an optical maser medium in a static magnetic field of arbitrary strength in the Z direction and in an electromagnetic field composed of traveling waves with both states of polarization and with both +z and -z directions. An integral formulation of a truncated phenomenologic density matrix is introduced to treat the degeneracy of the atomic energy levels within the natural width. This integral is an exact solution of the phenomenological differential equation for the density matrix which was introduced by Wilcox and Lamb. The inherent degeneracy in the electromagnetic field is included by treating the field in a classical manner. The integral formulation is iterated to yield the first- and third-order contributions to the electric polarization vector P in a spatial element dr, and the electric field and the electric polarization are made self-consistent in this spatial element by using coefficients in Maxwell's equations which are slowly varying functions of position and time. Several specific cases are discussed.

R. A. F.

**A66-13205**

## MEASUREMENT OF THE ENERGY AND POWER OF LASERS.

R. A. Valitov, Iu. A. Kalinin, and V. M. Kuz'michev.

Izmeritel'naya Tekhnika, May 1965, p. 37-41.)

Measurement Techniques, May 1965, p. 438-443. 36 refs. Translation.

Discussion of means for measuring the pulse energy and power of lasers under continuous operating conditions. Calorimeters and ponderomotive meters are currently being used, as are meters based on the photoelectric effect of radiation. Calorimetric meters are the most widely used, as they are simple to make and operate, are easy to calibrate, and can be employed as absolute energy and power meters. The use of calorimeters with solid absorbing loads is apparently restricted to small and medium-energy lasers. Liquid calorimeters or ponderomotive meters are used to measure energy and power at high levels. High-level energy can also be measured by means of calibrated optical radiation attenuators.

R. A. F.

**A66-13233**

## PHYSICAL FUNDAMENTALS OF LASERS [PHYSIKALISCHE GRUNDLAGEN DES LASERS].

H. Freitag.

Internationale Elektronische Rundschau, vol. 19, Jan. 1965, p. 11-14. In German.

Explanation of laser operation for communications engineers. As the operation of lasers is based on laws of atomic physics with which the communications engineer is not necessarily familiar, some of the basic principles are presented in a manner expected to be understandable to the normal communications engineer. The concepts of population inversion and induced emission are introduced and the principal optical apparatus is described.

R. A. F.

**A66-13247**

## INVESTIGATION OF A LASER TRIGGERED SPARK GAP.

Winston K. Pendleton (USAF, Air University, Institute of Technology, Wright-Patterson AFB, Ohio) and Arthur H. Guenther (USAF, Systems Command, Research and Technology Div., Weapons Laboratory, Kirtland AFB, N. Mex.).

(American Nuclear Society, Meeting, Ann Arbor, Mich., Apr. 1964, Paper.)

Review of Scientific Instruments, vol. 36, Nov. 1965, p. 1546-1550. 11 refs.

The influence of parameters affecting the laser triggering of a high voltage electrical sphere-sphere gap has been experimentally investigated. Of primary interest was the delay time between arrival of the laser pulse and current flow across the gap. This delay was studied as a function of total laser beam power (0-80 MW); dielectric gas (SF<sub>6</sub>, N<sub>2</sub>, air); gas pressure (100-1400 torr); electrode spacing (0.4-1.5 cm); gap electric field (10-100 kV/cm); and

focus point location between two 5 cm diam stainless steel spheres. Delay times less than 10 nsec were observed in SF<sub>6</sub> at atmospheric pressure with corresponding low jitter. For the cases studied delay times varied inversely with the electric field, gas pressure, and focus point distance from the anode surface. Above a certain laser beam power the delay time was not a significant function of laser power for the range studied. Applications of laser triggering are discussed with a description of current and future research areas.

(Author)

**A66-13248**

## LASER PHOTOGRAPHY OF HYPERVELOCITY PROJECTILES.

Warren V. Trammell (General Motors Corp., Defense Research Laboratories, Santa Barbara, Calif.).

Review of Scientific Instruments, vol. 36, Nov. 1965, p. 1551-1553.

Description of a photographic system which is capable of taking photographs of hypervelocity projectiles in a free-flight range. The system consists of a Q-switched laser, a simple lens camera, and related triggering circuitry. The film size is 73 x 95 mm which permits an image-object ratio of two. Typical photographs of hypervelocity projectiles traveling between 6.4 and 7.1 km/sec are presented.

M. F.

**A66-13260**

## QUANTUM STATISTICAL DYNAMICS OF LASER AMPLIFIERS.

A. E. Glassgold (New York University, New York, N.Y.) and D. Holliday (RAND Corp., Santa Monica, Calif.).

Physics Letters, vol. 17, July 15, 1965, p. 249, 250. 5 refs.

Army-supported research.

Application of a quantum statistical procedure for analyzing radiation fields interacting with other systems to a model laser amplifier consisting of a single mode of the radiation field interacting with an exciting system of two-state pumping molecules and with a damping system of oscillators. The complete solution for the density matrix of the radiation field is derived for arbitrary initial fields, the essential step being the introduction of a particular complete set of orthogonal operators for expanding the density matrix.

A. B. K.

**A66-13278 #**

## THE INFLUENCE OF CRYSTALLINE TEXTURE ON ELECTRON SPIN RESONANCE LINEWIDTHS IN SYNTHETIC RUBY.

D. A. Curtis, C. J. Kirkby, and J. S. Thorp (Durham University, Dept. of Applied Physics, Durham, England).

British Journal of Applied Physics, vol. 16, Nov. 1965, p. 1681-1685. 6 refs.

Measurement of the widths of the -1/2 to -3/2 and -1/2 to +3/2 transitions in synthetic vapor-phase ruby as a function of polar angle  $\Theta$  for specimens showing different degrees of mosaic imperfection. Anisotropic line broadening was observed with maxima near  $\Theta = 45^\circ$ . The magnitude of the broadening was proportional to the mean mosaic misorientation giving an increase in total linewidth of up to two times for misorientations of less than  $1^\circ$ .

M. F.

**A66-13307**

## NEODYMIUM GLASS LASER WITH SINGLE PULSE DURATION CLOSE TO THE LIMIT.

V. I. Malyshev, A. S. Markin, V. S. Petrov, I. I. Levkoev, and A. F. Vompe (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(ZHETF Pis'ma v Redaktsiiu, vol. 1, June 15, 1965, p. 11.)

JETP Letters, vol. 1, June 15, 1965, p. 159, 160. 7 refs. Translation.

[For abstract see Accession no. A66-10262 01-16]

**A66-13308**

## OBSERVATION OF A FAST PHOTOIONIZATION AUREOLE AND OF A CONCENTRATED LONG LIVED IONIZATION CLOUD DUE TO A SHOCK WAVE FROM A SPARK IN A LASER BEAM.

G. A. Askar'ian, M. S. Rabinovich, M. M. Savchenko, and A. D. Smirnova (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(ZHETF Pis'ma v Redaktsiiu, vol. 1, June 15, 1965, p. 18.)

JETP Letters, vol. 1, June 15, 1965, p. 162-164. Translation.

[For abstract see Accession no. A66-10263 01-16]



**A66-13310**

EFFECT OF A FOCUSED RUBY-LASER BEAM ON THE RUBY.  
T. P. Belikova and E. A. Sviridenkov (Akademii Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(ZHETF Pis'ma v Redaktsiiu, vol. 1, June 15, 1965, p. 37.)

JETP Letters, vol. 1, June 15, 1965, p. 171, 172. Translation.

[For abstract see Accession no. A66-10265 01-16]

**A66-13311****ATOMIC BEAM LASERS.**

N. G. Basov and V. S. Letokhov (Akademii Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(ZHETF Pis'ma v Redaktsiiu, vol. 2, July 1, 1965, p. 6.)

JETP Letters, vol. 2, July 1, 1965, p. 3-5. 7 refs. Translation.

[For abstract see Accession no. A66-10448 01-16]

**A66-13313****LASER WITH RADIATION DIAGRAM OF DIFFRACTION WIDTH.**

A. L. Mikaelian, A. V. Korovitsyn, and L. V. Naumova.

(ZHETF Pis'ma v Redaktsiiu, vol. 2, July 1, 1965, p. 37.)

JETP Letters, vol. 2, July 1, 1965, p. 22-24. Translation.

[For abstract see Accession no. A66-10450 01-16]

**A66-13325****MULTIREFLECTOR FABRY-PEROT LASER RESONATORS.**

Nobuaki Kumagai, Masanori Matsuhara, and Hiroki Mori (Osaka University, School of Engineering, Osaka, Japan).

Electronics and Communications in Japan, vol. 47, July 1964,

p. 12-21. 5 refs. Translation.

Theoretical analysis of the oscillation characteristics of multireflector Fabry-Perot lasers with three or more reflectors. The practical design problem of constructing a laser resonator with optimum suppression of unwanted modes is discussed. Equivalent circuits of the laser resonator are presented. As a design example, the He-Ne gas laser is discussed; it provides optimum suppression of all but one axial mode.

R.A.F.

**A66-13327****RELAXATION OSCILLATION IN SOLID-STATE MASER DUE TO MAGNETIC-FIELD MODULATION.**

Shuichi Hayasaka and Humio Inaba (Tohoku University, Research Institute of Electrical Communication, Sendai, Japan).

Electronics and Communications in Japan, vol. 47, July 1964, p. 55-57. 5 refs. Translation.

Observation of unusual, high-power, relaxation-oscillation phenomena in a multilevel solid-state ruby maser by modulating the magnetic field. For this purpose, an alternating magnetic field was superimposed on the dc magnetic field and CW pumping power was applied. A block diagram of the maser system is given. A spectrogram of the relaxation-oscillation waveform is included.

R.A.F.

**A66-13376 \*****ON OBSERVATIONS OF THE UPPER ATMOSPHERE BY RUBY LASER.**

Kiyoshi Nishikori, Tooru Ishida, Kenji Uchikura, Kooji Muranaga, Masaru Ichinose, Yoshihisa Masuda, Takeshi Nagatake, Motokazu Hirano, and Takashi Igarashi.  
Radio Research Laboratories, Journal, vol. 12, July 1965, p. 213-222. 7 refs.

Summary of preliminary observations of the upper atmosphere carried out (in Japan) in March, 1965, with the aid of a normal-pulse laser-beam transmitter. An electronic counter was used to obtain height distributions of the scattered laser light and the external noises. The relation between the height distributions and the weather, the detectable altitude range of scattered laser echoes, and the use of laser light in tropospheric observations are discussed.

A.B.K.

**A66-13431****NEODYMIUM-GLASS LASER WITH PULSED Q SWITCHING.**

N. G. Basov, V. S. Zuev, and Iu. V. Senatskii (Akademii Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(ZHETF Pis'ma v Redaktsiiu, vol. 2, July 15, 1965, p. 57.)

JETP Letters, vol. 2, July 15, 1965, p. 35, 36. Translation.

[For abstract see issue 24, page 3597, Accession no. A65-36826]

**A66-13477****PERIODIC VARIATION OF THE QUALITY FACTOR OF THE CAVITY OF A He-Ne GAS LASER BY MEANS OF A VIBRATING QUARTZ - MODULATION OF THE LIGHT BEAM [VARIATION PERIODIQUE DU COEFFICIENT DE QUALITE DE LA CAVITE D'UN LASER A GAZ He-Ne A L'AIDE D'UN QUARTZ VIBRANT MODULATION DU FAISCEAU LUMINEUX].**

Norbert Segard, Jean Pouliquen, Emmanuel May, and Francis Lafitte (Lille, Université, Faculté des Sciences; Institut Supérieur d'Electronique, Lille, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 261, no. 17, Oct. 27, 1965, p. 3328, 3329. In French.

Experimental investigation in which an optically polished quartz was introduced into the cavity of a He-Ne gas laser and was excited by an electric signal at a frequency of 100 kc. Modulation of the light beam emitted by the laser ensued. The modulation process of the coherent light beam emitted by the He-Ne laser is described as being of the narrow-band type. Due to the fact that the modulating device was placed inside the cavity, the light beam maintained its weak divergence.

M.M.

**A66-13478****PREPARATION AND STUDY OF SINGLE CRYSTALS OF THE DOUBLE MOLYBDATES OF SODIUM AND THE RARE EARTHS IN VIEW OF THEIR USE AS LASER MATERIALS [PREPARATION ET ETUDE DE MONOCRISTAUX DE MOLYBDATES DOUBLES DE SODIUM ET DE TERRES RARES, EN VUE DE LEUR UTILISATION COMME MATERIAUX "LASERS"].**

Rudolf Heindl, Françoise Damay, Roger Der Agobian, and Jean Loriers (Centre National de la Recherche Scientifique, Laboratoire Central de Télécommunications, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 261, no. 17, Oct. 27, 1965, p. 3335-3338. In French.

Description of a method for the preparation of single crystals of the double molybdates  $\text{NaLn}(\text{MoO}_4)_2$  (where Ln designates one of the rare earth elements), in particular double molybdates of sodium and lanthanum doped with praseodymium, neodymium or terbium. Following the preparation of simple molybdates by fritting, the double molybdates were obtained by crystallization in a flux and were used in the synthesis of single crystals, in accordance with Czochralski's method. The properties of the crystals thus obtained are described including the melting point, density, crystalline parameters, and absorption and fluorescence spectra. The neodymium-doped single crystals were successfully used to obtain the laser effect.

M.M.

**A66-13688****HIGH-PERFORMANCE WEATHER RADAR.**

R. L. Robbani (U.S. Army, Electronics Command, Electronics Laboratories, Meteorological Div., Ft. Monmouth, N.J.).

IEEE Transactions on Aerospace and Electronic Systems, vol. AES-1, Oct. 1965, p. 185-192.

A maser preamplifier designed into an X-band weather radar set (AN/MPS-34) increased the radar's sensitivity by 12.5 db to an overall 118.5 dbm. Many low-performance, obsolete sets could be converted to a high-performance system through the inclusion of a maser. A qualitative discussion of the maser's operation is presented, and the quantitative effects of the maser low noise temperature on the radar's overall noise figure is derived. The meteorological targets not previously detectable are analyzed, and anticipated target detection is forecast.

(Author)

**A66-13694****SAFETY WITH LASERS.**

Harrison A. G. Stone (Secretariat for Electronic Test Equipment, New York University, New York, N. Y.).

Ordnance, vol. 50, Nov.-Dec. 1965, p. 315-318.

Discussion of potential hazards inherent in lasers, with suggestions for safe handling of these devices. It is pointed out that the output of even a weak laser can readily be 100,000 times as intense as that of the surface of the sun. It is considered that biological effects of high-energy microwave radiation, X rays,  $\gamma$  rays, and other radioactive emissions are the most similar to the effects of lasers. Skin and eye damage, and deep visceral lesions are among the effects of exposure to laser activity which have been observed in humans and animals. Adequate training, use of nonglossy surfaces in work areas, periodic ophthalmic examination, use of goggles, and proper work habits are said to be the best ways of avoiding injury. It is emphasized that accurate knowledge of the subject is still very limited. Because energy densities of  $5 \times 10^{-6}$  joule/cm<sup>2</sup> reaching the eye in pulses as short as 200  $\mu$ sec can damage parts of the retina, a maximum exposure of one tenth this critical value has been proposed.

F. R. L.

**A66-13743****INCORPORATION OF A LASER INTO THE ARM OF AN INTERFEROMETER FOR MEASUREMENT OF TRANSIENT PHASE CHANGES.**

Edward Thornton (Illinois Institute of Technology, Research Institute, Chicago, Ill.).

Journal of Applied Physics, vol. 36, Nov. 1965, p. 3539-3541. 6 refs.

Research sponsored by the Illinois Institute of Technology.

An interferometer is described in which a He-Ne laser has been introduced into one of the arms to act as a coherent light source, eliminating the use of a beam splitter and making more efficient use of available light. The interferometer has been used with 0.63- $\mu$  laser light to observe the fringe shift produced in a small transient plasma with submicrosecond time resolution. Electron densities of the order of  $10^{15}$ /cm<sup>3</sup> over a path length of 15 cm were measured, close to the sensitivity limit for the unrefined experimental setup. The use of a laser source with long light paths and narrow beam width gave good discrimination against plasma light.

(Author)

**A66-13744****PERFECTION OF RUBY LASER CRYSTALS.**

L. S. Birks, J. W. Hurley, and W. E. Sweeney (U.S. Naval Research Laboratory, Washington, D. C.).

Journal of Applied Physics, vol. 36, Nov. 1965, p. 3562-3565. 6 refs.

Ruby laser crystals grown by three different methods have been examined by X-ray topography and double-crystal rocking curves. Flame-fusion grown material is the least perfect. It usually has a few zones per centimeter that are tilted from the general matrix by 1 to 2 min of arc; the angular range of misorientation within the matrix is about 20 to 30 sec of arc. Flux grown ruby is intermediate in perfection with few or no gross imperfections and angular misorientation of 15 to 20 sec of arc. The most perfect ruby is grown by the Czochralski method. No gross imperfections have been observed; the angular misorientation is about 5 sec of arc over mm sized areas and 10 sec of arc over cm sized areas.

(Author)

**A66-13753****SEMICONDUCTOR SURFACE DAMAGE PRODUCED BY RUBY LASERS.**

Milton Birnbaum (Aerospace Corp., El Segundo, Calif.).

Journal of Applied Physics, vol. 36, Nov. 1965, p. 3688, 3689. 6 refs.

Contract No. AF 04(695)-469.

Discovery of a new effect - a system of parallel straight lines - in the surface damage produced in semiconductors with a ruby laser. Regular patterns of cracks were also observed in the damaged areas of most semiconductors. The parallel grooves are considered to be probably the result of diffraction effects which occur in the neighborhood of the focal spot of a lens. It is considered that the regular crack patterns for a GaAs sample are related to the cleavage habits of semiconductors.

R. A. F.

**A66-13874 #****CdS OPTICAL GENERATOR DURING TWO-PHOTON EXCITATION BY A RUBY LASER [OPTICHESKII GENERATOR CdS PRI DVUKH-FOTONNOM VOZBUZHDENII RUBINOVYM LAZEROM].**

V. K. Koniukhov, L. A. Kulevskii, and A. M. Prokhorov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). Akademiia Nauk SSSR, Doklady, vol. 164, Oct. 11, 1965, p. 1012-1015. 16 refs. In Russian.

Description of the main characteristics of a CdS single-crystal optical generator during two-photon excitation by a ruby laser. The coefficient of two-photon absorption is determined at 300°K for various flux densities of the incident radiation. It is found that this coefficient is proportional to the density of the luminous flux and agrees in absolute value with theoretical estimates. Estimates are made of the inverse population and of the probability of nonradiative transitions.

A. B. K.

**A66-13888 #****MEASUREMENT OF LASER RADIATION ENERGY [IZMERENIE ENERGI IZLUCHENIIA O.K.G.].**

A. A. Besshaposhnikov, A. E. Voloshin, and I. Kh. Kuchuberiia (Gosudarstvennyi Komitet Atomnoi Energii, Fiziko-Tekhnicheskii Institut, Sukhumi, Georgian SSR).

Priboi i Tekhnika Eksperimenta, vol. 10, Sept.-Oct. 1965, p. 204-206. 10 refs. In Russian.

Description of a device for measuring the output power of pulsed lasers in the range from 0.01 to 10 joules. The device comprises a "rat nest" - type bolometer, a calibrated stable amplifier, and an oscilloscope that records the output signal.

V. Z.

**A66-13889 #****INVESTIGATION OF THE TIME CHARACTERISTICS DURING THE GENERATION OF GIANT PULSES BY LASERS [ISSLEDOVANIE VREMENNYKH KHA RAKTERISTIK PRI GENERATSII GIGANTSKIKH IMPUL' SOV OPTICHESKIMI KVANTOVYMI GENERATORAMI].**

V. L. Broude, V. I. Kravchenko, and M. S. Soskin (Akademiia Nauk Ukrainskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR).

Priboi i Tekhnika Eksperimenta, vol. 10, Sept.-Oct. 1965, p. 207-210. In Russian.

Description of a circuit set up for the study of the kinetics of giant pulse generation by lasers with prismatic shutters. The circuit permits (1) observations and photographing of laser giant pulses at various operating modes of the oscillators, and (2) the investigation of the relationship between the time-dependent variations in the Q factor of the resonator and the time-dependent development stages of the giant pulse being generated.

V. Z.

**A66-13890 #****OPTICAL RESONATOR USING CYLINDRICAL MIRRORS WITH A VARIABLE RADIUS OF CURVATURE [OPTICHESKII REZONATOR NA TSILINDRICHESKIKH ZERKALAKH S PERESTRAIVAE MYM RADIUSOM KRIVIZNY].**

V. M. Klement'ev and Iu. D. Kolomnikov (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Institut Fiziki Poluprovodnikov, Novosibirsk, USSR).

Priboi i Tekhnika Eksperimenta, vol. 10, Sept.-Oct. 1965, p. 210, 211. In Russian.

Discussion of the operation of a laser using cylindrical mirrors with a radius of curvature that can be modified by bending the mirrors in a special device. Operation of the resonator at a wavelength of 6328 Å using 3 x 10-cm glass plates, 1 mm thick and coated with ZnS and MgF<sub>2</sub>, with a radius of curvature of about 3.8 m, is described.

V. Z.

**A66-13951****EXCITATION AND INVERSION MECHANISMS IN GAS LASERS.**

W. R. Bennett, Jr. (Yale University, Sloane Physics Laboratory, New Haven, Conn.).

New York Academy of Sciences, Annals, vol. 122, May 28, 1965, p. 579-595. 25 refs.

USAF-supported research.

Discussion of recent developments in the field of gas lasers. Modifications of the optical pumping and electron impact methods (two main excitation methods) are described, and radial profile and

saturation characteristics are analyzed. Possible high power three-level gas laser systems and the ionized noble gas lasers are studied. A schematic illustration is included of the experimental facility used to study the radial profile and saturation characteristics of the He-Ne laser. B.B.

#### A66-13952

##### MODE CONFINEMENT AND GAIN IN JUNCTION LASERS.

W. W. Anderson (Stanford University, Stanford, Calif.).

*IEEE Journal of Quantum Electronics*, vol. QE-1, Sept. 1965, p. 228-236. 19 refs.

Contract No. DA-28-043-AMC-00446(E).

For a three layer dielectric sandwich, the center dielectric region must have a dielectric constant higher than the outer regions and some finite thickness for a wave to be "bound" to the center region. The transverse propagation constants for even TE modes have been calculated when the dielectric sandwich is unsymmetrical. The resultant field distributions are used to derive a formula for the gain of a junction laser of the form  $\alpha = (\alpha_1 + E_{H3}/nR + \xi \alpha_2)/g$  where the  $\alpha_n$ 's are the attenuation (or gain) constants associated with the various regions of the junction structure. Curves of  $P/nR$ ,  $\xi$ , and  $g$  as a function of active region thickness are given from which the condition for laser oscillation or the net gain or loss per unit length of a given device may be found. (Author)

#### A66-13953

##### CYCLOTRON RESONANCE INTERACTION OF MICROWAVES WITH ENERGETIC ELECTRONS.

J. L. Hirshfield, I. B. Bernstein (Yale University, Dept. of Engineering and Applied Science, New Haven, Conn.), and J. M. Wachtel (Yale University, New Haven, Conn.).

*IEEE Journal of Quantum Electronics*, vol. QE-1, Sept. 1965, p. 237-245. 25 refs.

Grant No. NGR 07-004-028; Contract No. AF 19(628)-2448; NSF Grant No. GP-3161.

Quantum mechanical and classical descriptions of microwave interaction with energetic electrons near cyclotron resonance which underlie the gain mechanism in the electron cyclotron maser are reviewed. Experimental studies designed to test the theory are discussed. A perturbation calculation is given which includes systematically the effects of rf electric and magnetic forces and finite transit time for electrons in the  $TE_{011}$  cavity used in the experiments. Nonlinear extensions of the theory which lead to estimates of the saturation level of this maser are discussed. (Author)

#### A66-13954

##### THEORY OF FM LASER OSCILLATION.

S. E. Harris and O. P. McDuff (Stanford University, Dept. of Electrical Engineering, Stanford, Calif.).

*IEEE Journal of Quantum Electronics*, vol. QE-1, Sept. 1965, p. 245-262. 17 refs.

Contract No. AF 33(657)-11144.

The paper presents a detailed analysis of FM laser oscillation which includes the effect of arbitrary atomic lineshape, saturation, and mode pulling. Such oscillation is achieved by means of an intracavity phase perturbation, and is a parametric oscillation wherein the laser modes oscillate with FM phases and nearly Bessel function amplitudes. One principal idea is that of the competition between different FM oscillations. The effect of the intracavity phase perturbation is to associate a set of sidebands with each of the previously free-running laser modes. While the free-running laser modes experienced their gain from essentially independent atomic populations, the competing FM oscillations to a large extent see the same atomic population; and in cases of interest the strongest of these oscillations is able to quench the competing weaker oscillations and establish the desired steady state condition. Results of the analysis include the following: threshold and power output, amplitudes and phases of all sidebands, frequency pulling of the entire oscillation, time domain behavior, distortion, supermode conversion efficiency, and effect of mirror motion. Results of numerical application of the theory to a number of specific cases are given. (Author)

#### A66-13955

##### DETAILED EXPERIMENTS ON HELIUM-NEON FM LASERS.

E. O. Ammann (Sylvania Electric Products, Inc., Sylvania Electronics Systems Div., Electronics Defense Laboratories, Mountain View, Calif.), B. J. McMurtry, and M. K. Oshman (Sylvania Electric Products, Inc., Sylvania Electronics Systems Div., Electronics Defense Laboratories, Optics Dept., Mountain View, Calif.).

*IEEE Journal of Quantum Electronics*, vol. QE-1, Sept. 1965, p. 263-272. 13 refs.

Research supported by the Sylvania Independent Research and Development Program.

Results are reported on the detailed measurements of the operating characteristics of an He-Ne FM laser oscillating at 6328 Å. Experiments were performed in both the "phase-locked" and the "FM" regions of operation, with particular emphasis on the FM region. In the phase-locked region, the pulsed output of the FM laser was observed and studied. In the FM region, measurements were made to study the laser power output, modulation index, and distortion (deviation from an ideal FM signal) as functions of the amplitude and frequency of the applied phase perturbation. Most of these experiments were performed under conditions of low laser excess gain (relatively few modes above threshold for the free-running laser); however, the results are useful for predicting the behavior of FM laser operation with larger excess gain. In addition to describing the practical operation of an FM laser, these experiments provide a check on the applicability of the FM laser theory of Harris and McDuff. An exact quantitative comparison between theory and experiment was not attempted, but the qualitative agreement is very good. (Author)

#### A66-13956

##### CONTINUOUS-DUTY ARGON ION LASERS.

E. F. Labuda, E. I. Gordon, and R. C. Miller (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

*IEEE Journal of Quantum Electronics*, vol. QE-1, Sept. 1965, p. 273-279. 9 refs.

The problems associated with the construction of continuous-duty dc excited ion lasers are indicated. Two solutions to the thermal dissipation and ion bombardment problem which have been experimentally tested and appear promising are described. These involve the use of axial magnetic fields with high current, low pressure, constricted arcs in large bore tubing and the use of metal-walled discharge vessels. The influence of an axial magnetic field on the properties of an ion laser is discussed, and the optical power levels which have been obtained are given. (Author)

#### A66-13980

##### LASER OSCILLATIONS AND SELF Q-SWITCHING IN TRIPLY ACTIVATED GLASS.

H. W. Gandy, R. J. Ginther, and J. F. Weller (U.S. Naval Research Laboratory, Washington, D.C.).

*Applied Physics Letters*, vol. 7, Nov. 1, 1965, p. 233-236. 10 refs. ARPA-Navy-supported research.

Description of the results of pulsed flash-lamp excitation experiments using confocal barium crown glass etalon triply activated with  $UO_2^{2+}$ ,  $Nd^{3+}$ , and  $Yb^{3+}$  at liquid nitrogen temperature. A series of pulse-excitation experiments was performed in which both the storage capacitor voltage and the series inductance of the flash-lamp circuit were varied to control the level as well as the time rate of optical excitation of the etalon. Typical results of these experiments are shown. It is noted that this series of experiments has indicated that, at the excitation level employed, it is possible to control the occurrence of optical oscillations in either or both ions by varying the rate and level of optical excitation of the etalon in spite of the fact that a radiationless energy transfer occurs from  $Nd^{3+}$  to  $Yb^{3+}$  with a transfer time of about 120  $\mu$ sec. It is pointed out that in room-temperature excitation of these triply activated glass etalons, it has been possible only to Q-switch  $Nd^{3+}$  using a slow rate of rise of excitation in which the maximum in the excitation pulse occurred about 2000  $\mu$ sec after pulse initiation. It would seem that the  $Nd^{3+}$  stimulated emission is self Q-switched before it can transfer sufficient energy to  $Yb^{3+}$  to cause this ion to exhibit stimulated emission in what would be essentially a three-level mode of operation. M.M.

**A66-13981**

STIMULATED BRILLOUIN AND RAMAN SCATTERING IN GASES. E. E. Hagenlocker and W. G. Rado (Ford Motor Co., Scientific Laboratory, Dearborn, Mich.).

*Applied Physics Letters*, vol. 7, Nov. 1, 1965, p. 236-238. 14 refs.

Discussion of the observation of stimulated Brillouin scattering in gases. Data are presented for nitrogen, but the effect has also been observed in argon gas. The velocity of sound calculated from the observed Brillouin frequency shift is compared with the velocity of sound calculated from known compressibility data. An experimental and theoretical comparison of stimulated Brillouin and stimulated Raman scattering is made for hydrogen and nitrogen gases. It is noted that the pressure dependence of the Raman data deviates from that predicted by the simple theory. However, the general agreement of the data for the two stimulated effects implies that no large anomalous gain was observed. The properties of the giant pulsed laser used were: peak power  $\sim 10$  Mw, beam divergence  $\sim 10^{-3}$  rad, and frequency width  $\sim .008$  cm $^{-1}$ . An amplifier with a gain of 10 was used with the laser to observe the stimulated Brillouin effect at the low-pressure points. M.M.

**A66-13983**

HIGH-POWER BREWSTER WINDOW LASER AT 10.6 MICRONS. T. J. Bridges and C. K. N. Patel (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

*Applied Physics Letters*, vol. 7, Nov. 1, 1965, p. 244, 245. 8 refs.

Experimental investigation in which high CW power output (2 to 5 watts) and efficiency (2 to 5%) around  $\lambda = 10.6 \mu$  were obtained using a Brewster window laser with stationary gas fills of pure CO $_2$  and also CO $_2$  with N $_2$ . The seven laser lines observed belong to the P-branch of the 00 $^1$  to 10 $^0$  vibrational-rotational band of CO $_2$ . Many of the lines could be obtained alone in a single longitudinal mode of the resonator. A significant increase in output was obtained on cooling the tube wall to  $-60^\circ\text{C}$ . The following conclusions are reached: (1) pure CO $_2$  can give high power outputs and efficiencies (by gas laser standards) but both are improved by addition of N $_2$ ; (2) output and efficiency are improved by cooling the gas. Analysis of the CO $_2$  laser showed that optical gain is approximately proportional to  $T^{-3/2}$ . In going from  $+40^\circ\text{C}$  to  $-60^\circ\text{C}$  a gain increase of about 1.5 would be expected. This gain increase is consistent with the observed power increase of 2 to 3 times since the laser is working well above threshold; and (3) the experiments show the possibility of building a compact portable laser giving high output at a single frequency around  $10.6 \mu$ . It is pointed out that such a laser could have applications, for example, in spectroscopy, communications, and nonlinear optics. M.M.

**A66-13984**

CW LASER ON VIBRATIONAL-ROTATIONAL TRANSITIONS OF CO. C. K. N. Patel (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

*Applied Physics Letters*, vol. 7, Nov. 1, 1965, p. 246, 247. 8 refs.

Discussion of precise measurements of V-R transition frequencies of the X $^1\Sigma^+$  state of CO ( $\pm 0.02$  cm $^{-1}$ ) obtained from an N $_2$ -CO system using a continuous gas flow laser scheme. The results warrant the conclusion that small but finite corrections are necessary to the previously published vibrational constants of X $^1\Sigma^+$  of CO. A summary of the experimental results is tabulated. For each of the vibrational bands reported in laser oscillation, the lower J transitions were seen only when the interaction region was cooled with methanol at  $-78^\circ\text{C}$ , while the high J transitions were seen only when the cooling was with water at  $\sim 15^\circ\text{C}$ . The result is considered to be that expected from theoretical considerations. No laser action was detected until a faintly visible milky white glow emanated from the region close to the two N $_2$  and CO feed ports into the interaction chamber. The glow, at low CO pressure, extended to  $\sim 30$ -40 cm in the interaction region towards the pumping port. The length of the glow shortened (with brightness increasing) as CO pressure was increased. It is pointed out that the presence of the glow coincident with CW laser action in CO militates strongly against vibrational energy transfer as a possible excitation mechanism, because it is unlikely that excitation of CO by N $_2$  will produce any visible radiation from the interaction region. M.M.

**A66-14059 #**

CONTROLLING THE EMISSION OF A GAS LASER [OB UPRAVLENI IZLUCHENIEM GAZOVOGO LAZERA].

L. N. Magdich.

*Radiotekhnika i Elektronika*, vol. 10, Nov. 1965, p. 2070-2072. In Russian.

Results of a quantitative investigation of the static characteristics of a gas-laser internal-modulation circuit realized with the aid of an electro-optical crystal inserted into the gas-laser resonator. The voltage dependence of the ratio between the radiation intensity reflected by the Brewster windows and the intensity passing through the electro-optical crystal is determined. It is shown that a system of maximum efficiency can be described by a condition relating the amplification factor of the mixture to the voltage on the crystal. A.B.K.

**A66-14123**

MODERN LOW-NOISE DEVICES.

L. S. Nergaard (Radio Corporation of America, RCA Laboratories, Princeton, N.J.).

IN: MODERN RADAR - ANALYSIS, EVALUATION, AND SYSTEM DESIGN.

Edited by R. S. Berkowitz.

New York, John Wiley and Sons, Inc., 1965, p. 432-469. 115 refs.

Consideration of low-noise devices, including low-noise TWT's, parametric amplifiers, Adler tubes, tunnel-diode amplifiers and converters, masers, and lasers. The gain mechanism involved in each is discussed briefly, and the gain, bandwidth, and noise figure of each is described. The state of development of these devices is reviewed, and the problems incidental to the application of them are outlined insofar as present experience with them permits. It is noted that the paper is a 1964 revision of an earlier paper. B.B.

**A66-14174**

FRACTURES PRODUCED IN GLASS BY A LASER BEAM [FRACTURES PRODUITES DANS LES VERRRES PAR UN FAISCEAU LASER]. Jean Davit and Michel Soulié (Compagnie Générale d'Electricité de Paris, Centre de Recherches, Marcoussis, Seine-et-Oise, France).

*Académie des Sciences (Paris), Comptes Rendus*, vol. 261, no. 18, Nov. 3, 1965, p. 3567-3570. 5 refs. In French.

Experimental investigation in which clearly established fractures were brought about in different kinds of glass by means of a laser. The laser operated on a wavelength of  $1.06 \mu$ . The types of glass investigated were neodymium-doped alkaline silicates and borosilicates. An interpretation is proposed to account for the fracture formation. M.M.

**A66-14273**

GENERATION OF LASER RADIATION BY DIRECT TRANSITIONS IN A SEMICONDUCTOR.

V. L. Vinetskii and V. S. Mashkevich (Akademiia Nauk Ukrainskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR).

(*Fizika Tverdogo Tela*, vol. 7, June 1965, p. 1898, 1899.)

*Soviet Physics - Solid State*, vol. 7, Dec. 1965, p. 1534, 1535. 9 refs. Translation.

**A66-14277**

MULTIMODE RESONATORS WITH A SMALL FRESNEL NUMBER - LOWEST-ORDER EIGENMODES.

Helmut K. V. Lotsch (Stanford University, W. W. Hansen Laboratories of Physics, Stanford, Calif.).

*Zeitschrift für Naturforschung*, vol. 20a, Jan. 1965, p. 38-48. 50 refs.

The Fabry-Pérot interferometer, the confocal and the spherical resonator systems are investigated. The lowest-order travelling-wave type eigenmodes are calculated. Numerical values for the diffraction losses are given. The smallest diffraction losses are obtained for the general-type eigenmode of a confocal resonator system. The eigenfunctions of an open-walled resonator show a point of inflection as their characteristic feature. They are complex if the Fresnel number is finite. When calculated over appropriate

surfaces, their imaginary part, in the region close to the axis, decreases as  $F$  increases. In that region the waves resonate between the reflectors. Towards the rim of the system the imaginary part increases rapidly as do the diffracted waves associated with the imaginary part. (Author)

#### A66-14278

##### CONICAL EMISSION IN RUBY LASERS WITH EXTERIOR MIRRORS [KEGELFÖRMIGE EMISSION BEI RUBINLASERN MIT ÄUSSEREN SPIEGELN]

D. Röss and P. Möckel (Siemens und Halske AG, Zentrallaboratorium, Munich, West Germany).

Zeitschrift für Naturforschung, vol. 20a, Jan. 1965, p. 49-53. In German.

Observation of an intensive reflection shaped like a hollow cone near the coherent center beam of a laser consisting of a polished ruby rod between two plane mirrors, when the axis of the rod was not parallel with that of the resonator. The apex angle of the cone increased as the angle between the two axes increased. It is experimentally and analytically shown that the conical beam is formed by the total reflection from the polished surface of the ruby rod of those light rays which are diverted from the central beam by diffraction and scattering while passing through the resonator.

R. A. F.

#### A66-14290

##### INVESTIGATION OF THE MODES OF A SHORT CONFOCAL RUBY LASER WITH A FIXED MIRROR [UNTERSUCHUNG DER MODEN EINES KURZEN KONFOKALEN RUBINLASERS MIT FESTEN SPIEGELN]

D. Röss, G. Gehr, and W. Heinlein (Siemens und Halske AG, Zentrallaboratorium, Munich, West Germany).

(Deutsche Physikalische Gesellschaft, Tagung, Munich, West Germany, Apr. 1964, Paper.)

Zeitschrift für Naturforschung, Ausgabe A, vol. 20a, Feb. 1965, p. 256-263. 7 refs. In German.

Investigation of the position dependence of the emission-vs-time spectrum, the optical emission spectrum, and the superposition spectrum of modes of a confocal ruby laser in the near field, at 4 Gc. When inversion is restricted to the zone around the rod axis, lower-order transverse modes alternate with degraded eigenfrequencies, and the emission is unstable. At higher pumping energy levels, the emission - in the form of transverse modes of the highest order is distributed over the entire cross section of the rod; the spectrum covers a wide band and is no longer degraded. The thermal shift of the lines during the laser pulses causes the frequency of the emission at a particular point to vary with time. Consequently, a particular mode can exist for only a short duration during a laser pulse.

D. P. F.

#### A66-14291

##### HOLLOW-CONE SHAPED EMISSION OF MODES WHICH ARE TOTALLY REFLECTED IN NEODYMIUM-GLASS LASERS [HOHLKEGELFÖRMIGE EMISSION TOTALREFLEKTIERTER MODEN IN NEODYM-GLASLASERN]

D. Röss (Siemens und Halske AG, Zentrallaboratorium, Munich, West Germany).

Zeitschrift für Naturforschung, Ausgabe A, vol. 20a, Feb. 1965, p. 264-266. In German.

Investigation of the spatial distribution of the preferential emission of various types of neodymium-glass lasers with plane-parallel mirrors at each end and a polished circumference at which there is total reflection. It was found that such lasers emit radiation with a hollow-cone configuration which typically have apex angles of 6 to 14°. Each type of mode has four hollow cones with the same opening but with different apices. Inasmuch as totally-reflecting modes have a low threshold, the axial modes from ruby lasers with open Fabry-Perot resonators were completely suppressed. If total reflection is prevented by roughening the circumference of the rod or - better yet - by surrounding it with an uneven boundary layer, this results in a selection of the axial modes and the emission of sharply directional plane waves.

D. P. F.

#### A66-14328

##### LIGHT MIXING IN FINITE PLASMA VOLUMES [LICHTMISCHUNG IN ENDLICHEN PLASMAVOLUMEN]

A. Salat (Institut für Plasmaphysik GmbH, Garching, West Germany).

Zeitschrift für Naturforschung, Ausgabe A, vol. 20a, May 1965, p. 689-695. 12 refs. In German.

EURATOM-supported research.

A third-order scattering process of laser light in a fully ionized plasma is considered, extending previous work by Kroll, Ron, and Rostoker. Two laser beams may cause the plasma to oscillate with relatively high amplitude if the difference of their frequencies approaches the electron plasma frequency. The light of either one of the beams or of a third beam may be scattered by the induced fluctuations. The plasma is described macroscopically by a cold electron fluid. Special emphasis is given to the finite dimensions of the scattering volume. The results give detailed information about the angular width and intensity of the scattered light. Marked differences in the use of a two and a three laser system are pointed out, the former giving less intensity, the latter being more difficult to realize experimentally.

(Author)

#### A66-14330

##### MODE SELECTIVE CHARACTERISTICS OF A PLANE-PARALLEL DIELECTRIC PLATE AS THE REFLECTOR FOR A LASER RESONATOR [MODENSELEKTIVE EIGENSCHAFTEN EINER PLANPARALLELEN DIELEKTRISCHEN PLATTE ALS REFLEKTOR EINES LASERRESONATORS]

G. Gehr and D. Röss (Siemens und Halske AG, Zentrallaboratorium, Munich, West Germany).

(Deutsche Physikalische Gesellschaft, Tagung, Düsseldorf, West Germany, 1964, Paper.)

Zeitschrift für Naturforschung, Ausgabe A, vol. 20a, May 1965, p. 701-705. 8 refs. In German.

Analysis of the strong axial and transverse mode selectivity exhibited by a reflector of a laser resonator which has the resonance characteristics of a dielectrical standard. Generally speaking only those modes occur which are modes for the standard itself. The temperature dependence of the amplifying lines in a ruby laser is such that various successive modes may be emitted during the course of a single pump pulse. Using a plane-parallel glass plate as a reflector, it was hitherto possible to excite only one axial mode.

D. P. F.

#### A66-14331

##### SPIKEFREE EMISSION OF A CONTINUOUS RUBY LASER [SPIKEFREIE EMISSION EINES KONTINUIERLICHEN RUBINLASERS]

K. Görs (Siemens und Halske AG, Forschungslaboratorium, Munich, West Germany).

Zeitschrift für Naturforschung, Ausgabe A, vol. 20a, May 1965, p. 740, 741. 10 refs. In German.

Description of a technique for obtaining spikefree emission from a continuous ruby laser, based on (1) heavy doping of the ruby crystal (up to 0.04% chromium), (2) the use of long crystals (57 mm) with spherical quasi-confocal mirrors, and (3) suitable symmetry for the pump radiation. It is shown that in order for heavily-doped lasers to operate satisfactorily they cannot be pumped by radiation impinging on one end of the laser rod, but must be pumped concentrically to the rod circumference. In order to cool the laser rod, liquid nitrogen was used. Experiments with such an improved laser indicate that relatively spikefree operation may be achieved.

D. P. F.

#### A66-14332

##### MEASUREMENT TECHNIQUE FOR THE DETERMINATION OF THE RISE TIME AND THE OUTPUT POWER OF A SINGLE PULSE IN AN He-Ne LASER [EIN MESSVERFAHREN ZUR BESTIMMUNG VON EINSCHWINGZEITEN UND AUSGANGSLEISTUNG EINZELNER EIGENSCHWINGUNGEN BEIM He-Ne-LASER]

W. Demtröder and R. Kuhn (Freiburg, Universität, Physikalisches Institut, Freiburg im Breisgau, West Germany).

Zeitschrift für Naturforschung, Ausgabe A, vol. 20a, May 1965, p. 742, 743. In German.

Description of a technique which can be used to determine the rise time and the pulse output power of an He-Ne laser and which

## A66-14334

is based upon the use of a plate located in the resonant cavity between the spherical mirrors to change the Q of this cavity at a variable rate between 0 and 15 kc. The time duration of the laser pulses is recorded on an oscillograph using an amplifier for secondary electrons. The average pulse duration is then related to the interruption frequency of the plate in the resonator for different pumping levels.  
D. P. F.

## A66-14334

MEASUREMENT OF THE LOCAL ELECTRON TEMPERATURE AND ELECTRON DENSITY IN A  $\epsilon$ -PINCH BY MEANS OF THE SCATTERING OF A LASER BEAM [MESSUNG DER LOKALEN ELEKTRONENTEMPORATUR UND ELEKTRONENDICHTE IN EINEM  $\epsilon$ -PINCH MITTELS DER STREUUNG EINES LASER-STRAHLS].

Hans-Joachim Kunze (Institut für Plasmaphysik GmbH, Munich, West Germany).

(München, Technische Hochschule, Fakultät für Allgemeine Wissenschaften, Diplom-Physiker, Dissertation, Dec. 11, 1964.)  
*Zeitschrift für Naturforschung*, Ausgabe A, vol. 20a, June 1965, p. 801-813. 31 refs. In German.  
EURATOM-supported research.

The development of light scattering by a plasma as a diagnostic tool is reported, which allows the local measurement of electron density and electron temperature. After a résumé of known theoretical results the feasibility of scattering experiments is discussed. The ratio of scattered radiation to plasma radiation is estimated. The experimental setup is described. Using fiber optics, it was possible to measure the whole spectrum of scattered light by one pinch discharge only. Several types of obtained spectra are modified by collective effects between the particles in the plasma. The building up of the satellite lines in the spectra is found as well as the existence of a small central line, as was predicted by the theory. Absolute calibrations of intensities also show the decrease of the scattering cross-section. From the spectra plasma parameters could be derived.  
(Author)

## A66-14363 #

INTERACTION BETWEEN OPTICALLY CONNECTED LASERS BASED ON A GaAs p-n JUNCTION [VZAIMODEISTVIE OPTICHESKI SVIAZANNYKH LAZEROV NA p-n-PEREKHODE GaAs].

N. G. Basov, Iu. P. Zakharov, V. V. Nikitin, and A. A. Sheronov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).  
*Fizika Tverdogo Tela*, vol. 7, Nov. 1965, p. 3460, 3461. In Russian.

Investigation of circuits for optically connected lasers constructed on a GaAs p-n junction. In a study of a longitudinal and a transverse circuit it is found that in both cases the quenching efficiency is low, due to difficulties in accurately setting up the diodes on one base. It is found that the optical link between lasers can be improved by using diodes with two resonators, the directions of coherent radiation of which are mutually perpendicular.  
A. B. K.

## A66-14373 #

LASER INTERACTION WITH A MERCURY SURFACE.

Paul A. Silberg (Raytheon Co., Wayland, Mass.).

*Canadian Journal of Physics*, vol. 43, Nov. 1965, p. 2078-2085. 22 refs.

To understand better the effects produced by the interaction of pulsed laser energy with materials, an experiment was performed with a light pulse from a ruby laser and a mercury surface. No visible arc was observed with the use of a 50-joule 2.5-millisecond laser pulse; however, a mechanical impact was observed and photographed with a framing camera. From the still frames, an estimate of the impact energy was made. Several mechanisms were examined to account for the observed effect. A rapid vaporization process, producing a reaction force into the mercury surface, would seem to account for the observed phenomenon.  
(Author)

## A66-14455

IRRADIATION BY LASER EFFECT [IRRADIATION PAR EFFET LASER].

J. Berthelot.

*Revue Générale d'Electronique*, vol. 19, Oct. 1965, p. 21-25. In French.

Use of laser beams in the fields of biology and medicine to improve understanding of various vital processes. Numerous studies which have been made on the interaction of electromagnetic radiation with biological systems at low peak power levels, as compared with those which can be obtained from lasers, are discussed. The studies cover the regions of the interaction of monochromatic, relatively coherent radiation, the application of lasers to the understanding of biological systems, the determination of possible hazards, the adaptation of laser devices to diagnostic medicine and therapeutics, and correlation of the biological effects with the effects on physical systems in order to comprehend various discussed factors. F. R. L.

## A66-14500

MODE OF A CONTINUOUS RUBY LASER WITH A FABRY-PEROT RESONATOR [MODEN DES KONTINUIERLICHEN RUBINLASERS MIT FABRY-PEROT-RESONATOR].

Dieter Röss (Siemens und Halske AG, Zentrallaboratorium, Munich, West Germany).

*Zeitschrift für Naturforschung*, Ausgabe A, vol. 20a, Oct. 1965, p. 1348-1354. 6 refs. In German.

Account of a long-term investigation of a large number of ruby lasers with plane-parallel mirrors at room temperature to determine their mode of operation. The threshold level was found to be the same as that for ruby lasers with confocal resonators, whereas the output of the confocal type is theoretically limited and even for high pumping levels is restricted to the fundamental mode. By using unsymmetrical configurations pure modes of up to the fourth transverse order may be selected. A 100-cps modulation frequency for the pumping light results in thermally modulating the mode frequencies, which for short rods of 25 mm in length is greater than the mode separation. Continuous ruby lasers with Fabry-Pérot resonators are equivalent to gas refraction lasers with respect to beam concentration. Continuous ruby lasers are compared with pulsed lasers as regards frequency stability and it is shown that the latter are inherently more stable.  
D. P. F.

## A66-14514 #

PRODUCTION LASER WELDING FOR SPECIALIZED APPLICATIONS.

K. J. Miller and J. D. Nunnikhoven (Garrett Corp.; AiResearch Manufacturing Co., Los Angeles, Calif.).

*Welding Journal*, vol. 44, June 1965, p. 480-485.

This paper discusses use of the laser to weld intricate and critical subassemblies which are being incorporated into space vehicles and components. Also of interest to fabricators is the very apparent capability for this process to remove metal. Drilling holes 0.001 in. or less in diameter is a reality in even the highest melting temperature metals. Some researchers are reporting that laser welding is a practical joining method for wire and foil welding. Of particular interest is the capability of the process to fusion weld within thousandths of an inch to a glass ceramic seal obtaining a helium leaktight metallurgical bond without cracking or damaging the ceramic seal. One specific example of this type of welding is discussed and illustrated.  
(Author)

## A66-14517 #

LASER BEAM WELDING ELECTRONIC COMPONENT LEADS.

A. R. Pfluger and P. M. Maas (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Palo Alto, Calif.).

(American Welding Society, Annual Meeting, 45th, Detroit, Mich., May 4-8, 1964, Paper.)

*Welding Journal, Research Supplement*, vol. 44, June 1965, p. 264-s-269-s. 13 refs.

The basic objective of this study was to determine whether fusion welds could be made utilizing the light beam from a laser. The welds were to be such that they would be applicable to joining electronic-component leads. Several joint designs were investigated including cross-wire, cross-ribbon, wire-to-ribbon, and parallel wire joints. Most of the investigation was concerned with nickel wire and ribbon. Weld evaluation by visual and metallographic examination was performed and joint strength of parallel wire welds determined. Differences between laser welding and resistance cross wire welding are discussed, and how these differences influence

design of welded electronic circuitry is pointed out. It is suggested that other designs more suitable for laser welding be developed.

(Author)

#### A66-14538

EXPERIMENTAL STUDY OF A PLASMA GENERATED BY FOCUSING A LASER BEAM IN AIR [ETUDE EXPERIMENTALE DU PLASMA CREE PAR FOCALISATION D'UN FAISCEAU LASER DANS L'AIR].

Francis Floux and Pierre Veyrie (Commissariat à l'Energie Atomique, Centre d'Etudes de Limeil, Service de Physique Générale, Villeneuve-Saint-Georges, Seine-et-Oise, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 261, no. 19, Nov. 8, 1965, p. 3771-3773. In French.

Experimental investigation of the dimensions of a plasma resulting from the action of a focused laser beam on air at atmospheric pressure and room temperature. A shock wave caused by the breakdown of the gas under the effect of the focused laser beam is formed, and its principal effects are manifested during the first 120 nsec after the laser pulse discharge. The laser used had an energy output of 0.8 joules delivered in a 35-nsec period. If breakdown of the gas (which absorbs 0.4 joules of energy) did not occur, the illumination at the point of focus would be of the order of  $3 \times 10^{11}$  w/cm<sup>2</sup>. The phenomena accompanying the breakdown were photographed with an electronic camera triggered by the laser pulse by means of a photodiode and an amplifier. Two very distinct phases which were observed indicate that the process of plasma evolution is closely connected with the absorption of luminous energy during the course of breakdown.

D. P. F.

#### A66-14562

USE OF LASERS FOR MICROCIRCUIT RESISTANCE TRIMMING.

Joseph P. Segré (Raytheon Co., Missile Systems Div., Electro-Optical Systems Dept., Bedford, Mass.).

IN: NATIONAL ELECTRONICS CONFERENCE, CHICAGO, ILL., OCTOBER 25-27, 1965, PROCEEDINGS. VOLUME 21.

[A66-14553 05-09]

Conference sponsored by the Illinois Institute of Technology, the Institute of Electrical and Electronics Engineers, Northwestern University, the University of Illinois, Argonne National Laboratory, Electronic Representatives Association, Scientific Apparatus Makers Association, the Society of Motion Picture and Television Engineers, Iowa State University, Marquette University, Michigan State University, the University of Minnesota, Purdue University, the University of Michigan, the University of Notre Dame, Ohio State University, and the University of Wisconsin.

Chicago, National Electronics Conference, Inc., 1965, p. 48-51.

Discussion of the possible use of lasers for trimming microcircuit elements. The trimming of evaporated thin-film and silk-screened cermet-film resistors was attempted with CW and pulsed He-Ne, ruby, argon, and GaAs lasers. It is found that a ruby or neodymium-doped pulsed laser delivering at least 0.01 joules/pulse, and an argon type CW laser can be used for microcircuit trimming. In addition, future developments should make the GaAs laser suitable for this function.

P. K.

#### A66-14563

LASER INDUCED MODULATION OF INFRARED RADIATION IN SILICON (LIMIRIS).

R. A. DiCurcio, A. R. Riben, and A. A. Klebba (United Aircraft Corp., Hamilton Standard Div., Electronics Dept., Windsor Locks, Conn.).

IN: NATIONAL ELECTRONICS CONFERENCE, CHICAGO, ILL., OCTOBER 25-27, 1965, PROCEEDINGS. VOLUME 21.

[A66-14553 05-09]

Conference sponsored by the Illinois Institute of Technology, the Institute of Electrical and Electronics Engineers, Northwestern University, the University of Illinois, Argonne National Laboratory, Electronic Representatives Association, Scientific Apparatus Makers Association, the Society of Motion Picture and Television Engineers, Iowa State University, Marquette University, Michigan State University, the University of Minnesota, Purdue University, the University of Michigan, the University of Notre Dame, Ohio State University, and the University of Wisconsin.

Chicago, National Electronics Conference, Inc., 1965, p. 52-55.

7 refs.

USAF-supported research.

Description of a contactless method for measuring the minority carrier lifetime in silicon, using the laser-induced (photo) modulation of IR transmission in silicon (LIMIRIS) effect. The basic principles underlying the method involve measuring the decay of injected carriers in the silicon. Experiments indicate that the use of a ruby laser yields measurements of the surface lifetimes, while the use of a neodymium-doped glass laser may also yield data on the bulk lifetime. Under appropriate conditions, the method should be applicable to other semiconductors.

P. K.

#### A66-14583

A GAS LASER SMALL PARTICLE DETECTOR.

S. A. Schleusener (New Mexico State University, Dept. of Electrical Engineering, Las Cruces, N. Mex.) and A. A. Read (Iowa State University of Science and Technology, Dept. of Electrical Engineering, Ames, Iowa).

IN: NATIONAL ELECTRONICS CONFERENCE, CHICAGO, ILL., OCTOBER 25-27, 1965, PROCEEDINGS. VOLUME 21.

[A66-14553 05-09]

Conference sponsored by the Illinois Institute of Technology, the Institute of Electrical and Electronics Engineers, Northwestern University, the University of Illinois, Argonne National Laboratory, Electronic Representatives Association, Scientific Apparatus Makers Association, the Society of Motion Picture and Television Engineers, Iowa State University, Marquette University, Michigan State University, the University of Minnesota, Purdue University, the University of Michigan, the University of Notre Dame, Ohio State University, and the University of Wisconsin.

Chicago, National Electronics Conference, Inc., 1965, p. 186-190.

Research supported by the Iowa State Research Foundation, National Defense Education Act, and NSF.

Description of the use of a low-gain He-Ne gas laser as a small-particle detector. The output of this laser is extremely sensitive to the presence in its optical cavity of particles as small as a few microns in diameter. Using Stokes' settling law and layered sedimentation techniques for a gaseous medium, the single-particle detection capability can be extended to obtain particle-size distributions of given particulate samples. Very small particle concentrations can be used. Experience gained using a laser system in conjunction with these techniques is discussed.

P. K.

#### A66-14659 #

A GaAs p-n JUNCTION LASER WITH A NONUNIFORM INJECTION-CURRENT DISTRIBUTION [LAZER NA p-n-PEREKHODE GaAs S NERAVNOMERNYM RASPREDELENIEM TOKA INZHEKTSII].

N. G. Basov, Iu. P. Zakharov, V. V. Nikitin, and A. A. Sheronov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Fizika Tverdogo Tela, vol. 7, Oct. 1965, p. 3128-3130. In Russian.

Study of the distribution of injection current over the area of the p-n junction of a laser diode divided into two unequal parts. The emission spectra of the diode near the threshold are plotted for the case of equal injection-current densities in both parts of the diode and for the case of inhomogeneous excitation. The variation in the emission spectrum of the diode beyond the threshold during an increase in the injection current in the smaller part of the diode is ascertained.

A. B. K.

#### A66-14692 #

AN EVALUATION OF LASER PERFORMANCE IN MICROWELDING.

A. O. Schmidt, I. Ham (Pennsylvania State University, Dept. of Industrial Engineering, University Park, Pa.), and T. Hoshi (Kyoto University, Kyoto, Japan).

(American Welding Society, Annual Meeting, 46th, Chicago, Ill., Apr. 26-30, 1965, Paper.)

Welding Journal, Research Supplement, vol. 44, Nov. 1965, p. 481-s-488-s.

Evaluation of some related parameters in laser welding, as regards laser performance and some feasible approaches to production applications. Conditions are established for obtaining satisfactory welds in 0.005-in. and 0.010-in. thick Type 302 stainless steel, as well as 0.005-in., 0.010-in., and 0.015-in. thick 18% Ni

## A66-14707

maraging steel. It is thought that laser welding will permit an extension and simplification of some conventional microwelding techniques; it is noted, however, that additional parameters for effective welding operations must be established by further research and experiments in order to make the laser a more useful tool. B.B.

## A66-14707

### THOMSON SCATTERING MEASUREMENTS OF MAGNETIC ANNULAR SHOCK TUBE PLASMAS.

Richard M. Patrick (Avco Corp., Avco-Everett Research Laboratory, Everett, Mass.).

*Physics of Fluids*, vol. 8, Nov. 1965, p. 1985-1994. 16 refs. Contract No. AF 49(638)-1483.

Measurements of Thomson scattering from the plasma electrons created by high speed shock waves in a magnetic annular shock tube have been used to determine the electron density behind shock waves and some preliminary measurements of the electron velocity distribution. A Q-switched ruby laser furnished the light beam which was scattered by the plasma electrons. A rotating quartz prism furnished the Q-switching of the optical cavity for the ruby laser, and rather long Q-switched pulses were obtained (between  $10^{-7}$  and  $10^{-6}$  sec duration). The power level during the Q-switched pulse was between 30 and 100 mw. Rayleigh scattering from an air sample at various pressures was used to calibrate the power output of the laser and gave for all of the tests a simultaneous measure of the laser output power, while the Thomson scattering was being measured. The measurements of the electron density using the Thomson scattering and the plasma continuum intensities agreed within the scatter of the data. The electron temperature measurements obtained with the Thomson scattering showed that the electron temperature increased with increasing shock speed for a given initial condition.

(Author)

## A66-14771

### JUNCTION HEATING OF GaAs INJECTION LASERS DURING CONTINUOUS OPERATION.

M. H. Pilkuhn and H. S. Rupprecht (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N. Y.).

*IBM Journal of Research and Development*, vol. 9, Sept.-Nov. 1965, p. 400-404. 11 refs.

DOD-ARPA-Navy-supported research.

Discussion, for different cases, of the rise of the junction temperature during continuous operation of an injection laser that has been measured as a function of current. The dependence of the emitted light power on current is computed from the thermal data and compared with the experiment. The threshold current and the differential quantum efficiency for continuous operation are discussed.

(Author)

## A66-14826

### LASER DIGITAL DEVICES.

Walter F. Kosonocky (Radio Corporation of America, RCA Laboratories, Princeton, N. J.).

IN: SYMPOSIUM ON OPTICAL AND ELECTRO-OPTICAL INFORMATION PROCESSING TECHNOLOGY, BOSTON, MASS., NOVEMBER 9, 10, 1964, PROCEEDINGS. [A66-14818 05-08] Symposium supported by the Professional Group on Electronic Computers of the Institute of Electrical and Electronics Engineers, the New England Section of the Optical Society of America, the Greater Boston Chapter of the Association for Computing Machinery, and the Office of Naval Research.

Edited by J. T. Tippet, D. A. Berkowitz, L. C. Clapp, C. J. Koester, and Alexander Vanderburgh, Jr. Cambridge, Mass., Massachusetts Institute of Technology Press, 1965, p. 269-304. 27 refs.

Contract No. AF 30(602)-3169.

Study of research work on laser digital devices. A simplified model is developed for large signal response of laser materials, which was verified by spectroscopic measurements of saturable absorbers illuminated by outputs of ruby lasers, which are also described. The study results of two saturable absorbers are given: R transitions of an unpumped ruby crystal, and singlet transitions of phthalocyanine solutions. The applications of semiconductor lasers for digital devices are considered, and it is concluded that the semiconductor, current-injection lasers are ideal for this purpose because of their small size, high quantum efficiency, and

fast switching speed. Laser-inverter, laser-bistable, and a laser-monostable circuit, representative of typical switching circuits that could be implemented with semiconductor lasers, are examined. The efficient quenching of a GaAs oscillator by means of a dual oscillator structure is described.

M.L.

## A66-14827

### LIGHT AMPLIFICATION AND SWITCHING USING FIBER OPTICS AND LASER.

N. S. Kapany, G. M. Burgwald, and J. J. Burke, Jr. (Optics Technology, Inc., Palo Alto, Calif.).

IN: SYMPOSIUM ON OPTICAL AND ELECTRO-OPTICAL INFORMATION PROCESSING TECHNOLOGY, BOSTON, MASS., NOVEMBER 9, 10, 1964, PROCEEDINGS. [A66-14818 05-08] Symposium supported by the Professional Group on Electronic Computers of the Institute of Electrical and Electronics Engineers, the New England Section of the Optical Society of America, the Greater Boston Chapter of the Association for Computing Machinery, and the Office of Naval Research.

Edited by J. T. Tippet, D. A. Berkowitz, L. C. Clapp, C. J. Koester, and Alexander Vanderburgh, Jr. Cambridge, Mass., Massachusetts Institute of Technology Press, 1965, p. 305-320. 14 refs.

Contract No. Nonr-4333(00).

Theoretical and experimental investigation of waveguide coupling between adjacent parallel fibers, as a means of transferring radiation from one element to another. Approximate expressions are developed for the degree of coupling between 2 closely spaced slabs and fibers. Such coupling effects are also demonstrated, and beat-length variation is studied as a function of the wavelength of the incident radiation. It is noted that photometric studies are being made in order to measure the relative intensities of 2 coupled fibers as a function of wavelength and it is shown that a high degree of modulation has been achieved. Further studies are going on of configurations that would provide waveguide coupling, not only for closely spaced passive fibers excited by an external source, but also between active fibers, such as fiber lasers.

M.L.

## A66-14829

### LASER DEFLECTION AND SCANNING.

R. V. Pole, R. A. Myers, H. Wieder, and E. S. Barrekette (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N. Y.).

IN: SYMPOSIUM ON OPTICAL AND ELECTRO-OPTICAL INFORMATION PROCESSING TECHNOLOGY, BOSTON, MASS., NOVEMBER 9, 10, 1964, PROCEEDINGS. [A66-14818 05-08] Symposium supported by the Professional Group on Electronic Computers of the Institute of Electrical and Electronics Engineers, the New England Section of the Optical Society of America, the Greater Boston Chapter of the Association for Computing Machinery, and the Office of Naval Research.

Edited by J. T. Tippet, D. A. Berkowitz, L. C. Clapp, C. J. Koester, and Alexander Vanderburgh, Jr. Cambridge, Mass., Massachusetts Institute of Technology Press, 1965, p. 351-364. 15 refs.

Consideration of a new approach to the deflection of laser light. In this technique, the laser beam is not actually deflected, but instead the laser is caused to emit in the desired direction at a given time. It is shown that for such a system to be realizable, the resonator must initially be capable of emitting light in a multiplicity of directions - i.e., it must be directionally, or angularly degenerate. A single mode, or direction, is then chosen by lifting the degeneracy, thus permitting one mode to be favored above others. It is emphasized that since a laser oscillator is a nonlinear device, mode selection is reduced to a perturbation problem and the energies needed to accomplish it may be relatively small. Described are a number of optical resonators that have a suitably high angular degeneracy, and some mode selection schemes, by means of which this degeneracy can be lifted, are discussed. It is concluded that there is reason for optimism about the possibility of laser deflection by means of multimode cavities with dynamic spatial filters.

M.L.

## A66-14830

### LASER LIGHT REDISTRIBUTION IN ILLUMINATING OPTICAL SIGNAL PROCESSING SYSTEMS.



Justin Kreuzer (Perkin-Elmer Corp., Norwalk, Conn.).  
 IN: SYMPOSIUM ON OPTICAL AND ELECTRO-OPTICAL  
 INFORMATION PROCESSING TECHNOLOGY, BOSTON, MASS.,  
 NOVEMBER 9, 10, 1964, PROCEEDINGS. [A66-14818 05-08]  
 Symposium supported by the Professional Group on Electronic  
 Computers of the Institute of Electrical and Electronics Engineers,  
 the New England Section of the Optical Society of America, the  
 Greater Boston Chapter of the Association for Computing Machinery,  
 and the Office of Naval Research.  
 Edited by J. T. Tippett, D. A. Berkowitz, L. C. Clapp, C. J.  
 Koester, and Alexander Vanderburgh, Jr.  
 Cambridge, Mass., Massachusetts Institute of Technology Press,  
 1965, p. 365-369.

Comparison of four methods of forming a laser beam of greater  
 uniformity from a typical laser resonator. The four methods are:  
 (1) the use of only the central region of the beam, which involves  
 high energy losses; (2) apodization, in which a spatial filter of non-  
 uniform transmission is used to attenuate the bright central region  
 of the beam more than the edge, and thus make the transmitted beam  
 uniform; (3) a sum of spatial modes of the proper relative phases  
 and amplitudes, and (4) the use of a pair of aspheric elements,  
 achieving uniformity at minimum energy loss. M. L.

#### A66-14837 #

##### ATMOSPHERIC BREAKDOWN LIMITATIONS TO OPTICAL MASER PROPAGATION.

Richard G. Tomlinson (Ohio State University, Dept. of Electrical  
 Engineering, Antenna Laboratory, Columbus, Ohio).  
 (National Bureau of Standards, Conference on Atmospheric Limita-  
 tions to Optical Propagation, Boulder, Colo., Mar. 18, 19, 1965,  
 Paper.)  
 Journal of Research, Section D - Radio Science, vol. 69D, Nov.  
 1965, p. 1431-1433.  
 Contract No. AF 33(615)-2287.

Experimental investigation of optical maser-induced gas break-  
 down. The dependence of breakdown in argon on pulse shape as  
 well as optical power density is illustrated. The data were selected  
 to show a general correlation between the pulse shape and the time  
 required to produce a breakdown. Deviations of  $\pm 5$  nsec from this  
 relationship were observed. The breakdown in air exhibits grossly  
 the same characteristics as breakdown in argon, except that the  
 dependence on pulse shape is more complex than that shown for  
 argon. Breakdown data for air are also more erratic, apparently  
 due to the complexity of the gas mixture. It is shown that air break-  
 down by focused optical maser pulses is dependent on gas pressure,  
 optical power density, focused spot size, and the temporal variation of  
 optical power density. It appears that megawatt-type pulses of  $10^{-8}$   
 to  $10^{-7}$  sec duration should produce air breakdown at optical power  
 densities of about  $10^{10}$  watts/cm<sup>2</sup> if the cross-sectional area of the  
 optical maser beam is sufficiently large to produce negligible dif-  
 fusion loss. M. M.

#### A66-14853 #

##### THE USE OF LASERS TO SIMULATE RADIATION-INDUCED TRANSIENTS IN SEMICONDUCTOR DEVICES AND CIRCUITS.

D. H. Habing (Sandia Corp., Sandia Laboratory, Albuquerque,  
 N. Mex.).  
 (Institute of Electrical and Electronics Engineers, Annual Confer-  
 ence on Nuclear and Space Radiation Effects, 2nd, University of  
 Michigan, Ann Arbor, Mich., July 12-15, 1965, Paper.)  
 IEEE Transactions on Nuclear Science, vol. NS-12, Oct. 1965,  
 p. 91-100, 10 refs.  
 AEC-supported research.

Demonstration that a pulsed-infrared laser can be used as a  
 relatively simple, inexpensive, and effective means of simulating  
 the effects caused by intense gamma ray sources on semiconductors.  
 Experimental results are presented which show that the transients  
 induced in various types of silicon transistors when exposed to a  
 neodymium laser are essentially identical to those obtained when  
 the transistors are exposed to pulses of 25 Mev electrons from a  
 linear accelerator and 600 kvp flash X-ray machine. Good agree-  
 ment exists between the peak photocurrents obtained using these  
 three sources over a dose range of  $10^{-1}$  to  $10^4$  rads. Calculations  
 based upon published as well as experimental absorption data for  
 silicon show that energy deposition is very nearly uniform for the

wavelength of light obtained from neodymium lasers (1.06 microns -  
 1.17-ev photons). By defocusing the laser light beam, dose rates  
 in excess of  $10^{12}$  rads/sec (silicon) in  $40 \times 10^{-9}$  seconds over an  
 area of 50 cm<sup>2</sup> have been obtained from a Q-switched 10 megawatt  
 neodymium laser. This greatly exceeds the maximum dose rate of  
 $10^{11}$  rads/sec (silicon) over approximately 1 cm<sup>2</sup> attainable from  
 linear accelerators. A low energy pulsed laser has been focused  
 through a microscope to a spot size of 10 microns and used as a  
 probe to generate ionization in selected regions of semiconductor  
 devices. Individual transistors and monolithic integrated circuits  
 have been investigated to determine the contributions of various  
 regions of devices to the photocurrents observed at the device  
 terminals. (Author)

#### A66-14897 #

##### A STUDY OF CERTAIN CHARACTERISTICS OF A HELIUM-NEON LASER.

F. A. Korolev, A. I. Odintsov, and V. N. Mitsai.  
 (Optika i Spektroskopiia, vol. 19, July 1965, p. 71-77.)  
 Optics and Spectroscopy, vol. 19, July 1965, p. 36-39, 6 refs.  
 Translation.  
 [For abstract see issue 20, page 2968, Accession no. A65-31375]

#### A66-14898 #

##### STIMULATED EMISSION OF PRASEODYMIUM IN CALCIUM TUNGSTATE.

V. L. Bakumenko, G. S. Kozina, T. A. Kostinskaia, E. P.  
 Lupachev, and E. S. Rvacheva.  
 (Optika i Spektroskopiia, vol. 19, July 1965, p. 132.)  
 Optics and Spectroscopy, vol. 19, July 1965, p. 68. Translation.  
 Description of the obtaining of laser oscillation in calcium  
 tungstate crystals activated with trivalent praseodymium. It is  
 noted that the oscillations were studied in cylindrical samples of  
 about 5 mm diam and 40 mm length, with plane-parallel silvered  
 ends. The luminescence spectrum of the crystals in the visible,  
 taken at 77°K on an ISP-51 spectrograph, is illustrated. B. B.

#### A66-14899 #

##### SOME PROPERTIES OF LASERS FROM THE POINT OF VIEW OF THERMODYNAMICS.

Iu. T. Mazurenko.  
 (Optika i Spektroskopiia, vol. 19, July 1965, p. 156-158.)  
 Optics and Spectroscopy, vol. 19, July 1965, p. 85-87. Translation.  
 [For abstract see issue 20, page 2969, Accession no. A65-31376]

#### A66-14901

##### ANALYSIS OF STIMULATED RAMAN SCATTERING IN WAVE- GUIDES.

William G. Wagner and Shaul Yatsiv (Hughes Aircraft Co., Re-  
 search Laboratories, Malibu, Calif.).  
 IEEE Journal of Quantum Electronics, vol. QE-1, Oct. 1965, p.  
 287-294, 9 refs.

Analysis of Stokes radiation, excited by a giant pulse radiation  
 propagating along a rectangular waveguide. Equations are estab-  
 lished and solved for an arbitrary shape of the giant pulse. At high  
 gains the stimulated radiation is emitted at all angles. The maxi-  
 mum output is almost perpendicular to the exciting beam, and it  
 decreases as the forward and backward directions are approached.  
 Forward-backward ratios are sensitive to the detailed shape and  
 magnitude of the laser pulse. The large forward-backward ratio  
 for intense short laser pulses accounts for the observed results,  
 which are illustrated for a square and a parabolic pulse. In prac-  
 tice, a large number of waveguide modes are simultaneously excited,  
 resulting in intense excitation of vibrational modes in the medium,  
 and enhancement of the inverse Raman effect and of anti-Stokes gen-  
 eration. M. F.

#### A66-14903

##### BISTABLE TRAVELING-WAVE OSCILLATIONS OF ION RING LASER.

W. W. Rigrod and T. J. Bridges (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).  
IEEE Journal of Quantum Electronics, vol. QE-1, Oct. 1965, p. 298-303. 17 refs.

Observation of both spontaneous and controlled one-way TW (traveling-wave) oscillations in a spherical-mirror ring resonator excited by an argon ion laser in its  $\lambda$  4879.90 Å transition. The dc-excited argon ion laser in an optical ring resonator has been found to oscillate spontaneously in one circulatory direction, for all but a relatively narrow range of gain levels above threshold. Near threshold the TW oscillations occur in the direction opposite to that of the ionic drift motion, whereas at high excitation levels they can occur in either direction. The direction of TW oscillations at any level can be controlled or switched, either by means of an external mirror or a weakly resonant loss element which can be tuned to favor either direction. The tendency of the ion ring laser to oscillate in a single direction is attributed in part to the Doppler shift associated with the ion drift velocity, and chiefly to its large natural linewidth. Hole widths burnt in the gain-velocity profile, which are significant in mode competition, usually exceeded the mode spacing of the resonator by large margins. Physical arguments have been advanced to show that, when such large hole widths prevail, and spatial cross relaxation depends only on ion motions, only running waves can oscillate in a ring resonator, and moreover they will all oscillate in the same direction. Close to threshold, the preferred direction for TW oscillations corresponds to that for which the gain profile is Doppler-shifted to longer wavelengths, possibly because of slightly smaller scattering losses. (Author)

#### A66-14904

##### OUTPUT SPECTRA OF THE ARGON ION LASER.

T. J. Bridges and W. W. Rigrod (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).  
IEEE Journal of Quantum Electronics, vol. QE-1, Oct. 1965, p. 303-308. 17 refs.

The output spectra of an  $A^+$  laser in its  $\lambda$  4879.90 Å transition has been observed at various levels above threshold, in a ring resonator, a two-mirror resonator of the same longitudinal mode spacing (107 Mc/s), and another two-mirror resonator of about three times that mode spacing. Oscillations were restricted to the fundamental (Gaussian) mode. The  $A^+$  laser spectra display three novel features, hitherto unobserved in the oscillation spectra of neutral-gas lasers which appear to stem, at least in part, from its large natural line width: (1) at moderate levels above threshold, the spectra are extraordinarily stable, and usually characterized by gaps of many mode spacings between oscillations; (2) above a critical level, oscillations occur in random sequence at all resonances, with violent amplitude fluctuations at each frequency; (3) the time-average envelope of the unstable "multimode" oscillations exhibits three well-defined maxima, which give way to a single maximum at a higher excitation level. The line shift of the laser transition has been measured to within about 10 percent, by comparing oscillation frequencies at the center of symmetrical spectra in the two counter-circulating waves of the ring laser. (Author)

#### A66-14908

##### AUTOMATIC FREQUENCY CONTROL OF A LASER LOCAL OSCILLATOR FOR HETERODYNE DETECTION OF MICROWAVE-MODULATED LIGHT.

Russell Targ and W. D. Bush (Sylvania Electric Products, Inc., Sylvania Electronic Systems Div., Mountain View, Calif.).  
Applied Optics, vol. 4, Dec. 1965, p. 1523-1527.  
 USAF-supported research.

Description of the operation of an automatic frequency control system which tunes a laser local oscillator (LO) so as to seek, acquire, and track the frequency of an incoming laser signal, and automatically maintain a 2.5-Gc frequency offset to permit the retrieval of microwave information. The feasibility and practicability of using optical heterodyne detection for the demodulation of weak optical signals having microwave bandwidths are demonstrated. M. F.

#### A66-14909

##### MICROWAVE MODELS OF OPTICAL RESONATORS.

P. F. Checcacci and A. M. Scheggi (Consiglio Nazionale delle Ricerche, Centro Microonde, Florence, Italy).  
Applied Optics, vol. 4, Dec. 1965, p. 1529-1533. 29 refs.  
 USAF-supported research.

Application of a scaling method to the study of the characteristics of a laser resonator. Experimental tests performed on a Fabry-Perot resonator with plane square mirrors operating in the X band are described. Measurements of frequency and quality factors of the resonator modes along with field distributions are reported and the results discussed. Particularly the close correlation between mirror deformations and field patterns is shown. M. F.

#### A66-14919

##### BEAM CHARACTERISTICS OF RUBY OPTICAL MASERS.

T. S. Jaseja, M. K. Dheer, and D. Madhavan (Institute of Higher Technology, Dept. of Physics, Kanpur, India).  
Applied Optics, vol. 4, Dec. 1965, p. 1643-1647. 20 refs.

With our experimental setup the output characteristics of ruby lasers have been studied. The photographic study was made to measure the beam divergence. From these measurements, the angular spread of the maser beam is obtained as  $2.4 \times 10^{-4}$  rad, which is fairly close to the theoretical limit. At high input pumping energies, the beam divergence increases considerably. This is believed to be due to generation of more transverse modes. The light output from the maser is focused (by a lens of a long focal length) onto the photocathode of a photomultiplier tube. The output from the photomultiplier is then displayed on a spectrum analyzer. In this way, beat notes corresponding to simultaneous axial mode oscillations are obtained and studied. The linewidth of these beats is around 500 to 700 kc when the maser is operated near threshold. This is much smaller than it is possible to measure in a conventional maser. At high pumping powers, the linewidth increases up to 4 Mc or so. (Author)

#### A66-14920

##### BEAM DIVERGENCE MEASUREMENT FOR Q-SWITCHED RUBY LASERS.

R. W. Waynant, J. H. Cullom, I. T. Basil, and G. D. Baldwin (Westinghouse Electric Corp., Atomic Defense and Space Group, Surface Div., Baltimore, Md.).  
(Optical Society of America, Annual Meeting, 49th, New York, N.Y., Oct. 6-9, 1964.)  
Applied Optics, vol. 4, Dec. 1965, p. 1648-1651.  
 USAF-supported research.

A technique is presented which makes use of photographic film to obtain quantitative measurements of the intensity distribution in a Q-switched laser beam. A gamma curve for XR (extended range) film has been made under Q-switched laser exposure conditions. Typical contours of intensity distribution from both rotating reflector and Kerr cell Q-switched laser systems are presented. Significant changes in the area of the intensity contours have been noted. These changes could result in large energy density errors in experimental results. Possible causes of these changes in intensity distribution are given. (Author)

#### A66-14921

##### TWO LENSES TO COLLIMATE RED LASER LIGHT.

Daniel Malacara (Rochester, University, Institute of Optics, Rochester, N.Y.).  
Applied Optics, vol. 4, Dec. 1965, p. 1652-1654. 5 refs.

Research supported by the Instituto Nacional de la Investigación Científica de Mexico and the U. S. Army.

Description of two lenses to collimate the light from a He-Ne laser, with focal ratios  $f/4$  and  $f/2.65$ . These systems have good spherical correction, and the coma is small. These lenses can be used as collimators or objectives on a high precision interferometer using red as well as yellow monochromatic light. M. F.

**A66-14923****A STUDY OF MODES IN A  $\text{Br}_2$ -Ar LASER.**

K. K. Chow and T. B. Ramachandran (Microwave Associates, Inc., Burlington, Mass.).

Applied Optics, vol. 4, Dec. 1965, p. 1670, 1671. 5 refs. USAF-supported research.

Discussion of laser action in a bromine-argon mixture. The output contains four lines, separated by 3.92, 13.90, 3.78, and 21.60 Gc, each of which has width to support a number of cavity modes. Microwave beats are reported which can be identified as those between modes differing not only in longitudinal, but also in transverse, mode numbers. The number of beats observed totals to about one hundred. The experimental results agree with three groups. In comparison with the mode chart, the experimental results are plotted, in which the beats between modes are properly identified.

M. F.

**A66-14924****ELECTRODELESS EXCITATION OF He-Ne GAS LASERS.**

D. S. Smith, K. M. Baird, and W. E. E. Berger (National Research Council, Ottawa, Canada).

Applied Optics, vol. 4, Dec. 1965, p. 1673, 1674.

Study of electrodeless excitation of the discharge in a He-Ne gas laser tube. This excitation presents two attractive features when compared with internal electrode systems: mechanical simplicity due to the avoidance of seal-throughs, and absence of metal parts in the discharge with their attendant risk of contamination and sputtering cleanup. The application of the electrodeless excitation to voice transmission is discussed.

M. F.

**A66-14972 #****COHERENT LIGHT TRANSMITTED THROUGH OPTICAL FIBER.**

Ryuichi Hioki and Takeomi Suzuki (Tokyo, University, Dept. of Applied Physics, Tokyo, Japan).

Japanese Journal of Applied Physics, vol. 4, Oct. 1965, p. 817. 6 refs.

Experimental investigation of the speckle pattern that appears during light transmission through an optical fiber. The Fraunhofer pattern of a transmitted laser light beam is presented. A fiber with diameter of 60  $\mu$  and a length of 11.5 cm was used. Its end faces were not polished. Light of a He-Ne laser (6328 Å) was incident normally on the entrance face of the fiber. For comparison, a pattern of light transmitted through a diffusing plate is also shown. The spatial frequencies of the speckle pattern are determined by the shape of the light source, that is, the exit face of the fiber, and they decrease with the diameter of the fiber. When the middle portion of the fiber was distorted by hand, the pattern changed but its statistical aspects did not. A more interesting result was obtained when two parallel fibers, closely placed to each other, were used: in addition to the speckles which were observed in the case of a single fiber, fine distorted fringes were observed, which are the result of interference between the light waves from the independent fibers. The spatial frequency of these fine fringes was dependent only on the distance between the exit faces of the fibers, and was not affected by any other portion of the fibers, as expected. When the exit faces were brought closer to each other, these fringes broadened and were finally lost in the larger speckles.

M. M.

**A66-14973 #****LASER OSCILLATIONS IN SILICON TETRACHLORIDE VAPOR.**

Mitsuyoshi Shimazu and Yasuzi Suzuki (Hitachi, Ltd., Central Research Laboratory, Tokyo, Japan).

Japanese Journal of Applied Physics, vol. 4, Oct. 1965, p. 819. 6 refs.

Experimental investigation of the possibility of obtaining laser action in some Si I lines by exciting silicon tetrafluoride ( $\text{SiF}_4$ ), silicon tetrachloride ( $\text{SiCl}_4$ ), and ethyl silicate ( $\text{Si}(\text{OC}_2\text{H}_5)_4$ ). When the electrodeless high frequency discharge was passed through silicon tetrachloride vapor or a mixture of silicon tetrachloride vapor and neon, laser action was obtained on three lines, two at about 1.2  $\mu$  and one at about 1.6  $\mu$ . On the other hand, attempts to obtain laser action with silicon tetrafluoride and ethyl silicate vapor have so far been unsuccessful. It was also found that, under suitable conditions, two known laser lines of the neutral chlorine atom at 1.98  $\mu$  and 2.02  $\mu$  oscillate regardless of parent molecules.

It is noted that these two Cl I lines do not appear as stimulated emission, in contrast to the three newly observed lines.

M. M.

**A66-14974 #****TRANSIENT CHANGE OF EMISSION IN PULSED GaAs LASER.**

Manabu Saji and Yoshio Inuishi (Osaka University, Faculty of Engineering, Osaka, Japan).

Japanese Journal of Applied Physics, vol. 4, Oct. 1965, p. 820.

Experimental investigation of the transient response of the emission spectrum during pulse operation of a GaAs laser, and an examination of its correlation with other properties. The samples were fabricated by diffusing Zn into n-type Te-doped GaAs; they were immersed in liquid nitrogen to be operated by a flat-top current pulse. The threshold current at 77°K was 0.9 amp. The waveforms of spectral laser emission under current pulse application which were obtained with grating spectrometer and photomultiplier are shown together with an example of the shift of the emission spectrum during the current pulse measured at various times from the pulse front. The results show that, with increasing time from the pulse front, the modes of longer wavelength were enhanced, and those of shorter wavelength were diminished. Conceivable mechanisms for this shift toward longer wavelengths include: (1) change of energy gap due to lattice expansion by heating; (2) depletion of high energy electrons or lowering of the quasi-Fermi level at the N side of the depletion layer during the current pulse; and (3) increase of the electron or hole population at deeper donor or acceptor levels during the current pulse. The observed temperature shift of the spectral peak was 0.4 Å/°K near 77°K, in good agreement with Nathan's results, but differing appreciably from Konnerth's value of 1.2 Å/°K.

M. M.

**A66-14979 #****RADIATION DAMAGE AND ANNEALING OF GaAs LASER DIODE.**

Manabu Saji and Yoshio Inuishi (Osaka University, Faculty of Engineering, Osaka, Japan).

Japanese Journal of Applied Physics, vol. 4, Oct. 1965, p. 830, 831.

Study of radiation damage in GaAs, the effects of  $\gamma$ -ray irradiation from Co 60 on a GaAs laser diode and its annealing. In addition to a decrease of quantum efficiency, it was found that the lasing peak wavelength at 8414 Å before irradiation (at a forward current of 4.0 amp) shifted slightly to shorter wavelengths with increasing  $\gamma$ -ray irradiations. Curves of the output light intensity of each spectral peak vs the forward injection current are presented.

M. F.

**A66-14981****THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE EMISSION BEHAVIOR OF A RUBY LASER WITH RESPECT TO TIME [THEORETISCHE UND EXPERIMENTELLE UNTERSUCHUNGEN DES ZEITLICHEN EMISSIONSVERLAUFS EINES RUBINLASER].**

H. Weber (Berlin, Technische Universität, I. Physikalisches Institut, Berlin, West Germany).

(Deutsche Physikalische Gesellschaft, Herbsttagung, Düsseldorf, West Germany, 1964, Paper.)

Zeitschrift für Physik, vol. 188, no. 5, 1965, p. 444-467. 13 refs. In German.

Research supported by the Stiftung Volkswagenwerk.

Approximate solution of the rate equations for a ruby laser for large deviations from the steady state, by neglecting oscillation damping. The analytic solutions are compared with numerical solutions and experimental values. These large-amplitude solutions are seen to describe the spiking behavior and spike shape of the ruby quite well. The nonstationary behavior can be described by only one value  $Q^*$ , which characterizes the laser and includes all the special properties of the laser-resonator, such as loss rate, number of active modes, pumping rate, and transition probabilities. An experimental setup for determining  $Q^*$  is given. Formulas to describe the relationships among spike half-width, spiking frequency, maximum output power, steady-state values, and pumping power are derived and experimentally confirmed.

R. A. F.

**A66-15034**

PRODUCTION OF COHERENT RADIATION BY ATOMS AND MOLECULES (1964 NOBEL LECTURE) [PRODUCTION DE RAYONNEMENT COHERENT PAR LES ATOMES ET LES MOLECULES].

C. H. Townes (Massachusetts Institute of Technology, Cambridge, Mass.).

(Nobel Foundation, Lecture, Stockholm, Sweden, Dec. 11, 1964.)

Electronique, Oct. 1965, p. 359-372. 93 refs. In French.

[For abstract see issue 24, page 3596, Accession no. A65-36095]

**A66-15097**

THEORETICAL INTERPRETATION OF THE EVOLUTION OF A PLASMA GENERATED BY FOCUSING A LASER BEAM IN AIR [INTERPRETATION THEORIQUE DE L'EVOLUTION DU PLASMA CREE PAR FOCALISATION D'UN FAISCEAU LASER DANS L'AIR].

Jean-Louis Champetier (Commissariat à l'Energie Atomique, Centre d'Etudes de Limeil, Villeneuve-Saint-Georges, Seine-et-Oise, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 261, no. 20, Nov. 15, 1965, p. 3954-3957. In French.

Theoretical analysis - based on a one-dimensional model - of the phenomena observed when a plasma is generated by focusing a laser beam in air. The evolution of the luminous zone of a plasma of this type can be divided into two phases - the first (lasting for about 30 nsec) being the period in which the air absorbs the luminous energy supplied by the laser and the second being the period in which the generated plasma cools down. The model used for investigation of the plasma in the first phase is based upon the work of Ramsden and Savic. It is assumed that the mean path of the photons in the plasma is short and that the energy supplied by the laser will be absorbed in a thin layer, giving rise to a shock wave. It is also assumed that the section of gas behind the detonation wave is much more affected by lateral than by longitudinal expansion. These simple hydrodynamic assumptions are in agreement with experimental results.

D. P. F.

**A66-15106**

EFFECTS OF MOLECULAR ANISOTROPY ON THE PROPAGATION OF AN INTENSE LIGHT [EFFETS DE L'ANISOTROPIE MOLECULAIRE SUR LA PROPAGATION D'UNE LUMIERE INTENSE].

Gérard Hauchecorne and Guy Mayer (Compagnie Générale de Télégraphie sans Fil, Département de Physique Appliquée, Orsay Seine-et-Oise, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 261, no. 20, Nov. 15, 1965, p. 4014-4017. 9 refs. In French.

Description of experiments which reveal that a part of the energy of an intense light beam, initially parallel, concentrates itself spontaneously in place and in time as it traverses certain liquids. These concentrations were predicted by Chiao, Garmire and Townes. Measurement shows them to be sufficiently strong to explain the large discrepancy between the observed stimulated Raman and Brillouin effects in these liquids and the theoretical predictions which assume the exciting beam to be practically homogeneous. The study of the criteria for the appearance of these spontaneous convergences shows that the electric anisotropy of molecules plays an essential role.

M. F.

**A66-15109**

STUDY OF THE ENERGY OF IONS EMITTED BY A METAL TARGET STRUCK BY A LASER BEAM [ETUDE DE L'ENERGIE DES IONS EMIS PAR UNE CIBLE METALLIQUE FRAPPEE PAR LE FAISCEAU D'UN LASER].

Alain Ducauze, Gianfranco Tonon, and Pierre Veyrie (Commissariat à l'Energie Atomique, Centre d'Etudes de Limeil, Service Documentation, Villeneuve-Saint-Georges, Seine-et-Oise, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 261, no. 20, Nov. 15, 1965, p. 4039-4041. 5 refs. In French.

Experimental study of the energy and intensity of ions emitted by a metal target as a function of the characteristics of the laser and of the nature of the metal. The observed phenomena are found to be compatible with a thermal model.

M. F.

**A66-15171**

PERIPHERAL MODES IN A CHELATE LASER [MODES PERIPHERIQUES DANS UN LASER A CHELATE].

Y. H. Meyer (Ecole Polytechnique, Laboratoire de Physique, Paris, France).

Journal de Physique, vol. 26, Oct. 1965, p. 558-560. 5 refs. In French.

Comparison of the luminescence emitted on the axis of the cylindrical cell with that emitted by the lateral face of a chelate laser. The existence of an axial superradiance, and of a lateral stimulated emission clearly differing from the normal longitudinal stimulated emission, is shown by the difference in the oscillograms obtained. It is concluded that peripheral modes, obtained by reflection at the cylindrical liquid-silica interface, are present.

A. B. K.

**A66-15297 #**

LIDAR - A CAT HUNTER?

Myron G. H. Ligda (Stanford Research Institute, Menlo Park, Calif.).

Shell Aviation News, no. 328, 1965, p. 2-8.

Discussion of possible applications for airborne laser-radar light detection and ranging (lidar) systems. The basic characteristics of laser and lidar operation are reviewed. The use of an airborne lidar system, for making atmospheric measurements of importance for flying, is discussed. One such possible use, it is noted, is the detection of clear air turbulence (CAT). A feasible configuration for a co-axial airborne lidar transmit-receive unit is described.

P. K.

**A66-15333 #**

RATE OF PROPAGATION OF A HIGH-POWER LIGHT PULSE IN AN INVERSELY POPULATED MEDIUM [SKOROST' RASPROSTRANENIYA MOSHCHNOGO IMPUL'SA SVETA V INVERSNOM ZASELENNOM SREDE].

N. G. Basov, R. V. Ambartsumian, V. S. Zuev, P. G. Kriukov, and V. S. Letokhov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Akademiia Nauk SSSR, Doklady, vol. 165, Nov. 1, 1965, p. 58-60. 5 refs. In Russian.

Consideration of the rate of propagation of a high-power laser light pulse in a medium consisting of two inversely populated levels. From a comparison of attenuated and unattenuated signals before and after amplification it is found that preferential amplification of the forward part of a pulse with an exponentially increasing leading edge does not lead to a decrease in the pulse duration but to an additional shift of the pulse maximum.

A. B. K.

**A66-15347 #**

HEATING OF THIN SHEET DURING LASER WELDING [NAGREV TONKIKH LISTOV PRI SVARKE LAZEROM].

N. N. Rykalin and A. A. Uglov (Institut Metallurgii, Moscow, USSR).

Akademiia Nauk SSSR, Doklady, vol. 165, Nov. 11, 1965, p. 319-322. In Russian.

Discussion of the heating process in laser overlap welding of metal sheets, that takes into account the thickness of the overlapping layer, the energy distribution in the laser beam, and the heat transfer to the lower sheet via the contact surface. A relation describing the temperature field for copper sheets of various thicknesses, and at various light-flux densities, is derived and applied to the calculation of the temperature field and energy of a laser pulse.

V. P.

**A66-15352 #**

OBSERVATION OF PARAMETRIC AMPLIFICATION IN THE OPTICAL RANGE [NABLIUDENIE PARAMETRICHESKOGO USILENIYA V OPTICHESKOM DIAPAZONE].

S. A. Akhmanov, A. I. Kovrigin, A. S. Piskarskas, V. V. Fadeev, and R. V. Khokhlov (Moskovskii Gosudarstvennyi Universitet, Fizicheskii Fakultet, Moscow, USSR).

ZHETF Pis'ma v Redaktsiiu, vol. 2, Oct. 1, 1965, p. 300-305. 6 refs. In Russian.

Direct observation of the parametric amplification of an optical signal with a wavelength of  $1.06 \mu$  in a KDP crystal excited by intense pumping radiation at  $0.53 \mu$ . A neodymium-doped glass laser is

used both as a source of pumping power and of the signal to be amplified. The power level achieved is seen to be sufficient to drive a parametric light generator and to achieve continuous tuning of the frequency of coherent optical oscillations. V.P.

#### A66-15354 #

EFFECT OF INTENSE LASER RADIATION ON THE DISPERSION PROPERTIES OF "TRANSPARENT" CRYSTALS [O VLIYANII INTENSIVNOGO LAZERNOGO IZLUGHENIYA NA DISPERSIONNYE SVOISTVA "PROZRACHNYKH" KRISTALLOV].

M. S. Brodin, V. N. Vatulov, and S. V. Zakrevskii (Akademiia Nauk Ukrainskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR).

ZHETF Pis'ma v Redaktsiiu, vol. 2, Oct. 1, 1965, p. 317-320. 5 refs. In Russian.

Observation of the changes in dispersion properties of a medium under the effect of a laser pulse, during the spectral analysis of semiconductor crystals transparent to ruby-laser radiation. The results are seen to provide some indications concerning the mechanism of the change in properties. V.P.

#### A66-15365 #

NEC MASER FOR RADIO ASTRONOMICAL OBSERVATION USED AT THE RESEARCH INSTITUTE OF ATMOSPHERICS.

NEC Review, vol. 6, no. 3, 1965, p. 12, 13.

Brief description of a maser amplifier for radio astronomical observation developed by NEC's Central Research Laboratory. With this amplifier, great emphasis has been placed on high stable performance, and it has been made so that it can be adjusted and handled conveniently in field installations. It is noted that a microwave solid-state maser, operating at the X-band, is used for improving the sensitivity of the radiometer. A photograph and a block diagram of this maser are provided, and its characteristics are described. As an example of the observation data obtained by this maser, the chart record of Taurus A is shown. M.F.

#### A66-15481

TRANSMISSION THROUGH A TAPERED QUARTZ TUBE IN THE LASER NEAR FIELD.

H. J. Caulfield (Texas Instruments, Inc., Dallas, Tex.). Nature, vol. 208, Nov. 20, 1965, p. 773, 774.

Study, on an experimental basis, of the transmission through a tapered quartz tube in the laser near field on the position of the tube in the field. The theory involved is based on the fact that the laser near-field pattern for circular apertures is a function of  $a^2/\lambda X$ , where  $a$  is the aperture radius,  $\lambda$  the wavelength of the light (6328 Å for the He-Ne laser used), and  $X$  is the distance from the aperture. The per-cent energy transmission through the tube is plotted as a function of the equation for various values of  $a$ . It appears to be true, it is concluded, that the percentage transmission for a given tube depends on its position in the laser near field. M.L.

#### A66-15484

LASER BOMBARDMENT EFFECTS ON VACUUM SURFACES.

L. P. Levine, J. F. Ready, and E. Bernal G. (Honeywell, Inc., Research Center, Hopkins, Minn.).

Research/Development, vol. 16, Dec. 1965, p. 56-59.

Comparison of current research work on the emission of light, electrons, ions, and gases from opaque surfaces under bombardment by Q-switched laser light beams in vacuo. The details of a Q-switched laser are briefly reviewed, and the confusion as to whether the laser light effects are purely thermal phenomena is noted. Results are presented from 2 of several approaches being conducted in parallel by the Honeywell Research Center, supported by the Ballistic Research Laboratories in Aberdeen. In one approach a modification of the time-of-flight mass spectrometer principle is utilized for studying the ions ejected from a surface under bombardment. Design details of the spectrometer are outlined, and it is reported that the energetic ions (observed by Linlor) are not only of the base material but also of occluded gases. In the second approach, a quadrupole mass analyzer is used for determining the gases desorbed from the surfaces under bombardment. It is found that, so far, results indicate no gross differences with the theoretically predicted temperature

excursions, and it is considered possible to predict the ionic component of gas desorption from these same temperature excursions. It is found, however, that such predictions fail to account for the observed ion currents and energies by many orders of magnitude. M.L.

#### A66-15794 #

LASER DENSITY PROBE.

J. F. Newton and M. J. Walsh (Cornell Aeronautical Laboratory, Inc., Hypersonic Tunnel Dept., Buffalo, N. Y.).

AIAA Journal, vol. 3, Dec. 1965, p. 2335-2337.

Discussion of the results of a program to demonstrate the feasibility of and develop the required instrumentation techniques for a new type of gas density measuring system, using light scattered from a laser beam as the measured quantity. The straightforward principle involved and the experimental setup used are described, and typical results are shown. It is concluded that the data obtained demonstrate the feasibility of the laser density probe concept. Output was shown to be linear with density over three orders of magnitude. The two main factors limiting this range were residual laser light and data scatter. The former was reduced to the order of 1% in the experimental setup; the second was characterized by a standard deviation of 2 to 3%. The most probable range of use in air is from  $10^{-4}$  amagat upward. M.M.

#### A66-15836

A PROPOSAL FOR LASER LIGHT MODULATION.

Hiroki Mori and Masanori Matsuhara (Osaka, University, School of Engineering, Osaka, Japan).

Electronics and Communications in Japan, vol. 47, Sept. 1964, p. 94, 95.

Suggestion of a method for modulating light from a laser with a composite Fabry-Perot resonator using more than three multiple reflecting plates. If the parameters  $L_L$ ,  $L_1$ , and  $L_2$ , representing the width of the laser material and distances between reflecting plates, are properly chosen, the normalized Q of the resonant system,  $Q(f)$ , will be maximum at  $f_0$ , where  $f_0$  is the center frequency of the stimulated radiation spectrum. Slight changes in  $L_1$  and  $L_2$  will then change the frequency characteristic of  $Q(f)$ , while the resonant frequency stays the same. R.A.F.

#### A66-15853 #

STRUCTURE OF THE RADIATION FIELD OF A GAS LASER WITH SPHERICAL MIRRORS.

S. G. Zeiger, N. I. Kaliteevskii, E. E. Fradkin, and M. P. Chaika. (Optika i Spektroskopiia, vol. 19, Aug. 1965, p. 255-263.)

Optics and Spectroscopy, vol. 19, Aug. 1965, p. 144-148. Translation.

[For abstract see issue 24, page 3595, Accession no. A65-36050]

#### A66-15854 #

ON THE THRESHOLD POWER OF A LASER WITH DISTURBED OPTICAL ADJUSTMENT.

I. A. Rom-Krichevskaya, A. M. Ratner, and A. V. Meshcheriakov. (Optika i Spektroskopiia, vol. 19, Aug. 1965, p. 264-269.)

Optics and Spectroscopy, vol. 19, Aug. 1965, p. 149-152. 7 refs. Translation.

[For abstract see issue 24, page 3595, Accession no. A65-36051]

#### A66-15856 #

EFFECT OF MIRROR MISALIGNMENT ON THE LOSSES IN A FABRY-PEROT RESONATOR.

M. P. Vaniukov, V. I. Isaenko, V. P. Kalinin, and V. V. Liubimov. (Optika i Spektroskopiia, vol. 19, Aug. 1965, p. 286, 287.)

Optics and Spectroscopy, vol. 19, Aug. 1965, p. 161, 162. Translation.

[For abstract see issue 24, page 3589, Accession no. A65-36053]

## A66-15858

### A66-15858 #

#### LUMINESCENCE AND ABSORPTION OF EXCITED RUBY.

M. D. Galanin, V. N. Smorchkov, and Z. A. Chizhikova.

(Optika i Spektroskopiia, vol. 19, Aug. 1965, p. 296-298.)

Optics and Spectroscopy, vol. 19, Aug. 1965, p. 168-170.

Translation.

[For abstract see issue 24, page 3595, Accession no. A65-36055]

### A66-15861 #

#### PRODUCTION OF A POWERFUL PULSE OF RADIATION FROM A RUBY LASER USING AN ULTRASONIC TRAVELING-WAVE DIFFRACTION MODULATOR.

I. I. Adrianova, Iu. V. Popov, and V. E. Terentev.

(Optika i Spektroskopiia, vol. 19, Aug. 1965, p. 307-310.)

Optics and Spectroscopy, vol. 19, Aug. 1965, p. 176, 177. Translation.

[For abstract see issue 24, page 3596, Accession no. A65-36058]

### A66-15864

#### SCATTERING OF INTENSE LIGHT.

Walter C. Henneberger (Southern Illinois University, Dept. of Physics, Carbondale, Ill.).

Physical Review, 2nd Series, Section A, vol. 140, Dec. 13, 1965,

p. A1864-A1866, 5 refs.

The variation of scattering cross section with beam intensity is computed for the scattering of ruby-laser light on atomic hydrogen. The result contradicts that of an earlier calculation which omits the contribution of some important intermediate states. The scattering cross section is found to increase very slightly as the intensity of the incident light is increased. (Author)

### A66-15900 #

#### GENERATION THRESHOLD OF A RUBY LASER WITH PUMPING ENERGY DISSIPATION IN THE CRYSTAL.

D. N. Vylegzhanin and M. Kh. Zelikman.

(Radiotekhnika i Elektronika, vol. 10, June 1965, p. 1147-1150.)

Radio Engineering and Electronic Physics, vol. 10, June 1965,

p. 984-987, 6 refs. Translation.

[For abstract see issue 16, page 2326, Accession no. A65-26687]

### A66-15958

#### THE DEVELOPMENT OF A WIDE TUNING RANGE L-BAND TRAVELING WAVE MASER.

B. J. Walker (Department of Defense, Washington, D. C.).

IN: MILECON/9; CONFERENCE ON MILITARY ELECTRONICS, WASHINGTON, D. C., SEPTEMBER 22-24, 1965, CONFERENCE RECORD. [A66-15954 06-09]

Conference sponsored by the Military Electronics Group of the Institute of Electrical and Electronics Engineers.

New York, Institute of Electrical and Electronics Engineers, Inc., 1965, p. 33-37, 5 refs.

This paper describes the development of an experimental L-band traveling wave maser with exceptionally wide tuning range. Net gains of 40 db or more have been obtained over the frequency range 1.35 to 2.0 Gc with the maser operated in a liquid helium bath of 4.2°K. The excess noise temperature did not exceed 17°K over this frequency range. (Author)

### A66-16072

#### NONLINEAR OPTICAL REFLECTION FROM A METALLIC BOUNDARY.

Fielding Brown, Robert E. Parks, and Arthur M. Sleeper (Williams College, Williamstown, Mass.).

Physical Review Letters, vol. 14, June 21, 1965, p. 1029-1031,

8 refs.

Army-supported research.

Description of the unambiguous observation of second-harmonic light generated on reflection of a giant-pulse laser beam from the surface of a silver mirror. It is noted that the observations were consistent with a second-harmonic polarization proportional to  $\vec{E} \cdot \nabla \vec{E}$ . Since only the component of  $\vec{E}$  normal to the surface has a discontinuity at the boundary, the second-harmonic polarization would be proportional to  $\cos^2 \theta$ , where  $\theta$  is the angle between  $\vec{E}$

and the plane of incidence. The second-harmonic intensity would be proportional to  $\cos^4 \theta$ . The apparatus used to detect the effect and measure its angular dependence is described and illustrated.

B. B.

### A66-16149 #

#### POSSIBILITY OF USING LASER RADIATION TO CREATE A STRONG ELECTRON SOURCE [O VOZMOZHNOСТИ ISPOL'ZOVANIYA IZLUCHENIYA LAZERA DLIYA SOZDANIYA MOSHCHNOGO ISTOCHNIKA ELEKTRONOV].

O. V. Bogdankevich, V. Iu. Sudzilovskii, and A. A. Lozhnikov

(Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Zhurnal Tekhnicheskoi Fiziki, vol. 35, Nov. 1965, p. 2052, 2053.

In Russian.

Creation of a source of electrons by extraction from a plasmoid formed by local heating of a cathode by a laser beam. The experimental apparatus is diagramed. An electron current of 500 amp was obtained over a period of 80 nsec.

R. A. F.

### A66-16346 #

#### GENERATION OF THE $R_2$ RUBY LINE IN A DISPERSION RESONATOR [GENERATSIIA $R_2$ -LINII RUBINA V DISPERSIONNOM REZONATORE].

V. L. Broude, O. N. Pogorelyi, and M. S. Soskin (Akademiia Nauk Ukrainskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR).

Akademiia Nauk SSSR, Doklady, vol. 163, Aug. 21, 1965, p. 1342,

1343. In Russian.

Summary of the performance of a dispersion resonator in a ruby laser, showing that generation on both the  $R_1$  line and  $R_2$  line can be obtained using such resonators. A resonator with dispersion systems proposed by Holstein and Biberman is described, and illustrated by a diagram.

V. Z.

### A66-16378

#### EFFICIENT CONTINUOUS OPTICAL SECOND-HARMONIC GENERATION.

R. G. Smith, K. Nassau, and M. F. Galvin (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).

Applied Physics Letters, vol. 7, Nov. 15, 1965, p. 256-258, 7 refs.

Experimental achievement of efficient, continuous, optical second-harmonic generation using a Nd:YAG laser and a crystal of single-domain lithium niobate placed internal to the laser cavity. It is shown that by placing the crystal inside the laser, the resultant increase in power density at the fundamental gives rise to an increase in second-harmonic power of a factor of  $(1/T_1)^2$ , where  $T_1$  is the transmission of the reflectors at the fundamental (assuming the same crystal length-to-spot ratio in both internal and external operation). It is found that for typical continuous operating conditions ( $T \approx 1\%$ ), this represents an increase of four orders of magnitude in harmonic power. The experimental setup is described and the apparatus schematized. It is concluded that with the highest powers now available at 1.06  $\mu$  with the Nd:YAG laser (1-watt CW with  $T = 1\%$ ), it is conceivable that continuous powers at 5300 Å approaching 500 mw, and high-repetition, Q-switched powers in excess of 1 kw can be obtained, making harmonic generation a practical method of achieving a solid-state green source.

M. L.

### A66-16379

#### DETERMINATION OF PLASMA DENSITY BY LASER INTERFEROMETRIC AND CONTINUUM RADIATION INTENSITY MEASUREMENTS.

A. Boornard, L. J. Nicastro, and James Vollmer (Radio Corporation of America, Camden, N. J.).

Applied Physics Letters, vol. 7, Nov. 15, 1965, p. 258-260, 8 refs.

Experimental study in which interferometric and continuum radiation intensity measurements were performed on a high-temperature argon plasma arc. Equations concerned with the radiation of angular frequency, electron particle collision frequency for momentum transfer, and the number of interference rings produced by a uniform plasma are reviewed. Measurements were made close to the nozzle exit (about 0.2 cm downstream of the nozzle) where the temperature along the jet radius was nearly uniform. Interference of 3.391- $\mu$  radiation, detected by the accompanying change in

intensity of 0.6328- $\mu$  radiation, is reported. A commercially available gas-sheath stabilized-arc plasma generator (Thermal Dynamics F-80), which has an exit diameter of 0.95 cm and exhausts into the atmosphere, was used. The experimental arrangement is illustrated, and the operating conditions specified (arc current, 735 amp; arc voltage, 25 v; argon mass flow,  $8 \times 10^{-3}$  moles/sec). The average power transferred to the gas flow was estimated to be between 3.5 and 5.3 kw, from which the average temperature of the argon at the nozzle exit was estimated to be 13,500 to 15,400°K. The rate of fluctuation of the arc voltage under these conditions (1.3 kc/sec) is illustrated, as well as a typical variation in interferometer output voltage for two transits of the beam. The question of whether thermal equilibrium exists in the region of the jet traversed by the laser beam is also examined.

M. L.

**A66-16381****FREQUENCY SELECTIVE COUPLING TO THE FM LASER.**

S. E. Harris (Stanford University, Dept. of Electrical Engineering, Stanford, Calif.) and B. J. McMurtry (Sylvania Electric Products, Inc., Sylvania Electronic Systems Div., Electronic Defense Laboratories, Mountain View, Calif.).

*Applied Physics Letters*, vol. 7, Nov. 15, 1965, p. 265-267. 9 refs. Research supported by Sylvania Independent Research and Development Program; Contracts No. AF 33(657)-11144; No. AF 33(615)-2884.

Experimental and theoretical investigation in which it was found that if one of the end mirrors of an FM laser is replaced with a frequency-selective transmission etalon the total power obtainable from the laser may alternately be obtained as a single optical frequency. The method described provides an alternative to the supermode technique of Masser et al., and may make it possible to obtain high single-frequency optical power levels from wide inhomogeneously broadened atomic lines. The method is based on the fact that there is an optimum output coupling (mirror transmission) which allows the maximum power to be taken from the FM laser - and that whether this coupling is provided as a sum of equal increments to all modes, or instead is provided entirely to one mode, is not of significance. FM laser oscillation was obtained by using a KDP intracavity phase perturbation in an He-Ne laser (Spectra-Physics Model 116) operating at 6328 Å with an axial-mode interval of 100 Mc. One end mirror of the laser was replaced with a Fabry-Perot etalon having a free spectral range of 2.1 Gc and a resolution of about 30 Mc. A piezoelectric crystal was attached to the outer mirror of the etalon and a sawtooth voltage applied such that the etalon was scanned over its free spectral range. An analysis is given of the appropriate coupling for maximum power output, but it is concluded that the presented derivation is too restrictive and that the method should work with a variety of conditions of detuning and perturbation strength. It is expected that similar power enhancements could be obtained with a sufficiently large AM-type perturbation.

M. L.

**A66-16383****MODE COMPETITION AND SELF-LOCKING EFFECTS IN A Q-SWITCHED RUBY LASER.**

Hans W. Mocker (Honeywell, Inc., Systems and Research Dept., St. Paul, Minn.) and R. J. Collins (Minnesota, University, Dept. of Electrical Engineering, Minneapolis, Minn.).

*Applied Physics Letters*, vol. 7, Nov. 15, 1965, p. 270-273. 12 refs.

Experimental investigation of mode competition and mode coupling on a multimewatt peak power and nanosecond time scale as a function of cavity length, initial absorption, and position of the passive Q switch ruby laser. The experimental apparatus is schematically shown and its geometric layout is illustrated. Pulse characteristics for multimode oscillations are summarized. The results indicate that at fast buildup rates mode competition takes place such that the center mode in a mode triplet is completely extinguished; with large mirror spacings (e.g., 79.2 and 105.6 cm) and with the ruby at one side and the passive filter at the opposite side of the cavity, self-locking of the phases of many cavity modes is obtained, and the laser is operated as a pulse regenerative oscillator.

M. L.

**A66-16384****CW LASER OSCILLATION IN AN N<sub>2</sub>-CS<sub>2</sub> SYSTEM.**

C. K. N. Patel (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

*Applied Physics Letters*, vol. 7, Nov. 15, 1965, p. 273, 274. 6 refs.

Experimental study of CW laser oscillation at ten wavelengths between 11.48  $\mu$  and 11.55  $\mu$  from a N<sub>2</sub>-CS<sub>2</sub> system using a continuous flow gas laser. The experimental apparatus was similar to that used in a previous study of vibrational energy transfer from N<sub>2</sub><sup>+</sup>(v = 1) to CO<sub>2</sub> and N<sub>2</sub>O for producing laser action in CO<sub>2</sub> and N<sub>2</sub>O. The measured vacuum wavelength, measured frequency, and relative intensity of the laser wavelengths observed in the N<sub>2</sub>-CS<sub>2</sub> system are summarized in a table. Laser oscillation wavelengths were carefully measured with a 75-cm grating spectrometer to an estimated accuracy of about  $\pm 0.02$  cm<sup>-1</sup>. It was found that laser oscillation at each of the ten wavelengths occurred in a single longitudinal mode of the optical cavity; the length tuning of the optical cavity is seen to be critical for each of the transitions. This implies that the Doppler width of the lines seen in laser oscillation is either comparable with or smaller than the interorder spacing  $c/2L$  for the longitudinal modes of the optical cavity (in the given case  $c/2L = 62$  Mc). It is concluded that, in spite of careful measurement, it has not been possible to identify the transitions unambiguously, nor to assign them to any simple product such as CN, NS, CS, etc., which may be produced in abundance in the interaction region following dissociation.

M. L.

**A66-16385****HIGH-POWER LASER ACTION IN CO<sub>2</sub>-He MIXTURES.**

G. Moeller and J. Dane Rigden (Perkin-Elmer Corp., Norwalk, Conn.).

*Applied Physics Letters*, vol. 7, Nov. 15, 1965, p. 274-276.

Experimental investigation of high-power CW laser action in which enhanced power output of dc excited CO<sub>2</sub> lasers was obtained by the addition of He to the discharge, both in flowing and nonflowing systems. Power outputs of 62 mw/cm<sup>2</sup> are reported. It is found that He added to CO<sub>2</sub> has a larger effect on laser power output than the addition of N<sub>2</sub>, and that best results are obtained in a tube containing a flowing mixture of CO<sub>2</sub>, He, and N<sub>2</sub>. Cooling the discharge tube with forced air is found to increase the output power markedly in the flowing gas system. The tube is described, and laser power curves for near-optimum mixtures of static gases are presented. Three facts are noted: (1) CO<sub>2</sub> alone gave a substantial amount of power (> 4 times that of flowing CO<sub>2</sub>) and was enhanced by N<sub>2</sub> only at low tube currents, whereas at higher tube currents N<sub>2</sub> appears to quench laser action; (2) addition of 20 torr of He increased laser power fivefold and produced a curve that extends to high tube currents; and (3) power obtainable at optimum conditions in a static system was less than one-half that obtained with flowing gases.

M. L.

**A66-16387****MEASUREMENT OF THE 633-nm WAVELENGTH OF HELIUM-NEON LASERS.**

K. D. Mielenz, K. F. Nefflen, K. E. Gilliland, R. B. Stephens (National Bureau of Standards, Washington, D.C.), and R. B. Zipin (Sheffield Corp., Dayton, Ohio).

*Applied Physics Letters*, vol. 7, Nov. 15, 1965, p. 277-279. 13 refs.

Experimental investigation of gas laser wavelength in terms of the fundamental standard of length. In order to provide such information for the most commonly used type of laser, the wavelength of the 3s<sub>2</sub>-2p<sub>4</sub> transition of neon was measured by comparison of helium-neon lasers with a Kr 86 lamp, which was operated under conditions specified by the Comité International des Poids et Mesures. Three similar lasers were used in the measurement: one containing 7 parts of helium and 1 part of neon of natural isotopic abundance at an approximate total pressure of 2.5 torr, and two identical lasers containing 9 parts of He 3 and 1 part of Ne 20 at an approximate total pressure of 3.8 torr. A beam splitter was used to combine the light from the krypton lamp with that of the laser. For the laser containing natural neon, the vacuum wavelength obtained was found to be  $\lambda_{vac} = 632.99145$  nm, with an estimated imprecision of  $\pm 0.00002$  nm; for the two lasers containing the mixture of He 3 and Ne 20 the same wavelength was found,  $\lambda_{vac} = 632.99147$  nm, with an estimated imprecision of  $\pm 0.00003$  nm.

M. L.

**A66-16388****GAIN IN A DIFFUSELY PUMPED RAMAN AMPLIFIER.**

D. P. Bortfeld and W. R. Sooy (Hughes Aircraft Co., Aerospace Group, Culver City, Calif.).

*Applied Physics Letters*, vol. 7, Nov. 15, 1965, p. 283-285. 12 refs. Army-supported research.

Results of gain measurements of a Raman amplifier pumped by diffuse ruby radiation. In the technique the direction and polarization of the pump radiation is randomized, so that no stable coherence relations can exist between it and the Raman radiation. The method eliminates any filamentary structure and smooths out any temporal fluctuations in the pump radiation. The experimental configuration is illustrated, and both the distribution of power in the diffuse amplifier, and the measured gain as a function of wall illumination are shown. Assuming cylindrically uniform wall illumination, a Lambertian surface, and random polarization, and using the data of Damen et al. and McClung and Weiner, it is shown that the amplifier gain can be related to the average wall illumination by an approximate expression:  $G = 1 + (2.8 \pm 0.7) \times 10^{-9} J_w$ , where  $J_w$  is the wall illumination. M.L.

**A66-16517 #**

**MULTIPHOTON IONIZATION OF A HYDROGEN MOLECULE IN A STRONG ELECTRIC FIELD OF RUBY-LASER EMISSION [MNOGO-FOTONNAIA IONIZATSIYA MOLEKULY VODORODA V SIL'NOM ELEKTRICHESKOM POLE IZLUCHENIYA RUBINOVOGO LAZERA].** G. S. Voronov, G. A. Delone, N. B. Delone, and O. V. Kudrevatova (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). *ZHETF Pis'ma v Redaktsiiu*, vol. 2, Oct. 15, 1965, p. 377-380. In Russian.

Observation of multiphoton ionization of a hydrogen molecule under the action of ruby-laser emission with a field strength of approximately  $10^7$  v/cm. The probability of multiphoton ionization of a hydrogen molecule is found to be determined by the probability of absorption of less than nine quanta. The reason for this is thought to be the existence of resonance transitions in the hydrogen spectrum and broadening of the upper quantum levels in a strong electric field. A.B.K.

**A66-16541 #**

**WIDTH OF THE EMISSION SPECTRUM OF A MASER [O SHIRINE SPEKTRA IZLUCHENIYA KVANTOVOGO GENERATORA].** Iu. A. Tarasov.

*Akademiia Nauk SSSR, Doklady*, vol. 165, Nov. 21, 1965, p. 537-540. 7 refs. In Russian.

Calculation of the width of the emission spectrum of a ruby maser, using equations derived for the dynamics of emission in two-level systems. It is shown that the emission spectrum of such a maser narrows down to a certain limit that depends on the amount of illumination and the width of the spontaneous-emission spectrum. A.B.K.

**A66-16626****DYNAMICS OF A LASER WITH TWO MODES OF OSCILLATION.**

N. G. Basov, V. N. Morozov, and A. N. Oraevskii (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). (*Akademiia Nauk SSSR, Doklady*, vol. 162, June 1, 1965, p. 781-784.) *Soviet Physics - Doklady*, vol. 10, Dec. 1965, p. 516-518. 9 refs. Translation.

[For abstract see issue 17, page 2486, Accession no. A65-27772]

**A66-16628****EFFECT OF NOISE RADIATION ON THE OPERATION OF A RUBY LASER.**

B. I. Stepanov (Akademiia Nauk Belorusskoi SSR, Institut Fiziki, Minsk, Belorussian SSR), A. N. Rubinov, and S. A. Mikhnov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). (*Akademiia Nauk SSSR, Doklady*, vol. 162, June 11, 1965, p. 1030-1033.)

*Soviet Physics - Doklady*, vol. 10, Dec. 1965, p. 538-540. 11 refs. Translation.

[For abstract see issue 24, page 3594, Accession no. A65-35863]

**A66-16640****AN L-BAND TRAVELING WAVE MASER USING CHROMIUM-DOPED RUTILE.**

Sigfrid Yngvesson and Erik Kollberg (Chalmers University of Technology, Research Laboratory of Electronics, Gothenburg, Sweden).

*IEEE, Proceedings*, vol. 53, Nov. 1965, p. 1737, 1738. 7 refs. Research supported by the Swedish Technical Research Council.

Description of a traveling-wave maser (TWM), for which chromium-doped rutile ( $\text{Cr-TiO}_2$ ) is used, and which is intended for radio astronomy research at 21 cm. The most favorable performance of this L-band TWM is obtained when the dc magnetic field is oriented along the c-axis, allowing the use of both ion sites in the  $\text{TiO}_2$ . The inverted susceptibility at this operating point is measured as a function of chromium concentration. A slow-wave TWM, developed by combining the features of a dielectrically loaded Karp structure with those of a comb structure, is described. P.K.

**A66-16647****OPTIMUM DESIGNS OF ELLIPTICAL CAVITIES COMPARED WITH CYLINDRICAL ONES.**

K. Kamiryo, T. Kano, H. Matsuzawa, and M. Yoshida (Tohoku University, Research Institute of Electrical Communication, Sendai, Japan).

*IEEE, Proceedings*, vol. 53, Nov. 1965, p. 1750, 1751. 7 refs.

Study of factors affecting the efficiency of an elliptical cavity in transferring energy from a light source to a ruby laser. The optimum design of an elliptical cavity with reflectivity less than unity is determined, and its efficiency is shown to be fairly superior to that of a cylindrical cavity. P.K.

**A66-16650****LASER BEAM "SECURITY."**

Selig Kainer (International Telephone and Telegraph Corp., ITT Federal Laboratories Div., Nutley, N.J.).

*IEEE, Proceedings*, vol. 53, Nov. 1965, p. 1752, 1753.

Discussion of problems involved in securing a direct laser communications link against interception. The conditions under which the bandwidth of an intercepting system is comparable to that of a direct system are examined. It is suggested that, due to sunlight background noise and the resulting beam diffusion, the point-to-point laser link cannot generally be considered absolutely secure. To obtain maximum security, the link should be operated at minimum power and with maximum utilization of the frequency bandwidth, thus providing the minimum acceptable SNR. P.K.

**A66-16652****A MULTIPLE INTERNAL-REFLECTION FOLDED-PATH OPTICAL MASER GEOMETRY.**

A. J. DeMaria (United Aircraft Corp., Research Laboratories, East Hartford, Conn.).

*IEEE, Proceedings*, vol. 53, Nov. 1965, p. 1757, 1758. 5 refs.

Description of a folded-path rectangular laser configuration utilizing multiple internal reflections for obtaining long lengths of active media between the Fabry-Pérot reflectors of the laser. This configuration provides a small angular beam spread of the output beam, and a means of discriminating against unwanted modes that take other than the desired path. The implementation of the technique is discussed. P.K.

**A66-16662****PHOTON TUNNELS - THE WAVEGUIDES OF THE FUTURE?**

Bernard L. Lewis (Radiation, Inc., Palm Bay, Fla.).

*IEEE, Proceedings*, vol. 53, Nov. 1965, p. 1768, 1769.

Study of the possible use of a suggested photon "trapped wave" effect for developing optical waveguides. The experiments discussed give evidence that, under certain conditions, an optical beam can create its own waveguide as it propagates, so that it does not diverge with distance. Such a waveguide could be used to guide other radiation going in the same direction at or near the same time. P.K.



**A66-16669****SEARCH VIA LASER RECEIVERS FOR INTERSTELLAR COMMUNICATIONS.**

Monte Ross (Hallcrafters Co., Research and Development Dept., Chicago, Ill.).

IEEE, Proceedings, vol. 53, Nov. 1965, p. 1780.

Discussion of considerations involved in searching the sky for possible interstellar laser communications signals. It is suggested that the senders of such signals would choose to place a microwave subcarrier on an optical or IR carrier and place any low-frequency information modulation on the subcarrier. This would be done on the assumption that the receiver will not be a narrowband scanning receiver but a relatively broadband receiver with a number of optical and IR filters. Likely restrictions and considerations for the carrier frequency and for the type of signal transmitted are examined.

P. K.

**A66-16670****SIMPLE IMPROVEMENT OF AMPLITUDE STABILITY IN HELIUM-NEON GAS-LASERS.**

Viktor Met (Electro Optics Associates, Palo Alto, Calif.).

IEEE, Proceedings, vol. 53, Nov. 1965, p. 1780, 1781.

Description of a method of suppressing amplitude variations in the outputs of He-Ne gas lasers. These variations, it is noted, are caused by the scanning of the Doppler line by a succession of cavity modes, due to changes of the effective cavity length with temperature. By replacing one cavity reflector with a sinusoidally driven reflector, to modulate the effective cavity length, quieting factors from 10 to 100 can easily be obtained.

P. K.

**A66-16672****REGULAR PERIODICAL SPIKING OF A NEODYMIUM-GLASS LASER.**

A. J. Casella (Pennsylvania State University, Dept. of Physics, University Park, Pa.).

IEEE, Proceedings, vol. 53, Nov. 1965, p. 1782, 1783.

Description of regular periodic spiking observed in the output of a pulsed neodymium-doped borate glass laser at pumping levels slightly above threshold. The experimental conditions are reviewed. It is found that the maximum duration of a pulse train of regular spikes is dependent on the neodymium concentration and on the reflectivity of the mirror at the output end of the resonant cavity. A high-loss resonant structure, it is noted, enhances the regular periodic spiking.

P. K.

**A66-16675****LIFE PERFORMANCE OF PRISM Q SWITCHED LASER.**

W. L. Knecht (USAF, Systems Command, Research and Technology Div., Avionics Laboratory, Laser Technology Branch, Wright-Patterson AFB, Ohio).

IEEE, Proceedings, vol. 53, Nov. 1965, p. 1785, 1786.

Discussion regarding the life performance characteristics of an uncoated ruby laser Q-switched by the rotating prism that forms the end reflector of the laser resonator. The lifetime of each of the individual components comprising the laser is reviewed. Tests show, it is noted, that an initial period of activation is needed before the output energies are stabilized. At constant operating conditions, the spread in stabilized output energies is  $\pm 7.5\%$ . The laser threshold energy increases rapidly with the number of laser pulses.

P. K.

**A66-16753****EFFECT OF GROUND STATE ESR SATURATION ON RUBY LASER OUTPUT AT 90°K.**

A. Szabo and T. Igarashi (National Research Council, Div. of Radio and Electrical Engineering, Ottawa, Canada).

Applied Physics Letters, vol. 7, Dec. 1, 1965, p. 289, 290. 6 refs.

Outline of Fabry-Pérot interferometer observations of ruby laser output frequencies for a rod, cooled by conduction to 90°K, which could be simultaneously subjected to a saturating microwave field at the zero-field ESR frequency of 11.49 Gc. The experimental facility is described and illustrated, and its operation is discussed. It is found that the saturation results in partial or complete suppression of the  $\pm 1/2$  laser line, depending on the optical pump power.

B. B.

**A66-16754****CW HIGH-POWER CO<sub>2</sub>-N<sub>2</sub>-He LASER.**

C. K. N. Patel, P. K. Tien, and J. H. McFee (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

Applied Physics Letters, vol. 7, Dec. 1, 1965, p. 290-292. 7 refs.

Discussion of a high-power CO<sub>2</sub>-N<sub>2</sub> laser, with which is obtained in a CO<sub>2</sub>-N<sub>2</sub>-He system a CW power output of 106 watts on two P-branch rotational transitions of the 00<sup>0</sup>1-10<sup>0</sup>0 vibrational band of CO<sub>2</sub>. This laser has also been operated under a quasi-CW condition by exciting the discharge with rectified but unfiltered ac; it gave a peak laser output of 183 watts. The test facility is described, and its operation is explained. It is found that the addition of large amounts of helium is desirable in order to obtain high power output from a large-diameter CO<sub>2</sub>-N<sub>2</sub> laser.

B. B.

**A66-16756****INFRARED LASER OSCILLATION IN HBr AND HI GAS DISCHARGES.**

S. M. Jarrett, J. Nunez, and G. Gould (TRG, Inc., Melville, N.Y.).

Applied Physics Letters, vol. 7, Dec. 1, 1965, p. 294-296. 7 refs.

Contract No. AF 49(638)-1535.

Investigation of CW IR laser oscillation in gas discharges produced in the hydrogen halides HBr and HI. Oscillation was observed at six wavelengths in the region between 2.2  $\mu$  and 3.5  $\mu$ , three each in HBr and HI. The oscillations have been identified with 4d - 5p and 5d - 6p transitions in atomic Br and I, respectively. The results of measurements and identifications are tabulated, and the experimental facility is described and its operation is discussed.

B. B.

**A66-16763****PULSED LASER TRANSITIONS IN MANGANESE VAPOR.**

M. Piltch, W. T. Walter, N. Solimene, G. Gould (TRG, Inc., Melville, N.Y.), and W. R. Bennett, Jr. (Yale University, Sloane Physics Laboratory, New Haven, Conn.).

Applied Physics Letters, vol. 7, Dec. 1, 1965, p. 309, 310. 9 refs.

Contract No. AF 49(638)-1535.

Observation of laser action on five green lines and six IR lines as a result of pulsing the manganese discharge of a collision laser in the atomic vapor of neutral Mn. Transient population inversions are produced in this laser by preferential electron excitation of those atomic energy levels which are both close to and optically connected with the ground level. These inversions are inherently transient because of the metastability of the lower laser level. The gain coefficient of the strongest line at 5341 Å was 37 db/m. The observed pulse width of 20 nsec implies a peak power output of 300 watts.

R. A. F.

**A66-16771 \*****GAS LASER EXCITED IN THE PROCESS OF PHOTODISSOCIATION [GAZOVYI KVANTOVYI GENERATOR S VOZBUZHDENIEM V PROTSESSE FOTODISSOLTSII].**

T. L. Andreeva, V. A. Dudkin, V. I. Malyshev, G. V. Mikhailov, V. N. Sorokin, and L. A. Novikova (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 49, Nov. 1965, p. 1408-1410. 6 refs. In Russian.

Investigation of the parameters of a gas laser which uses photodissociation of CH<sub>3</sub>I and CF<sub>3</sub>I molecules to achieve population inversion. Specifically studied is the dependence of the generation threshold (the threshold electric power of a pulsed argon lamp) and output power of the laser pulse on the pressure of the working fluid. It is shown that there is a certain range of pressures at which the generation threshold has a minimum value, and that this pressure range for CH<sub>3</sub>I differs greatly from the range for CF<sub>3</sub>I.

V. P.

**A66-16773 \*****EFFECT OF DISCONTINUITIES ON THE OPERATING REGIMES OF SOLID STATE MASERS [VLIYANIE NEODNORODNOSTEI NA REZHIMY RABOTY KVANTOVYKH GENERATOROV NA TVERDOM TELE].**

A. F. Suchkov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 49, Nov. 1965, p. 1495-1503. In Russian.

Derivation of a system of two equations for electromagnetic field and population inversion, describing in the geometric optics approximation the nonstationary processes in solid state masers when the complex dielectric permittivity is discontinuous in a direction perpendicular to the maser axis, while the active medium is continuous along this axis. Conditions are determined in which the field of a maser can be given as a superposition of the fundamental oscillations of its resonator alone. Expressions are derived to calculate the operating regime of a maser with a thin active rod positioned along its axis, and operating regimes with undamped relaxation oscillations are established. V. Z.

**A66-16775 #**

SELF-MODULATION OF RADIATION OF A LASER WITH A TWO-MODE RESONATOR [AVTOMODULIATSIIA IZ LUCHENIIA OPTICHESKOGO KVANTOVOGO GENERATORA S DVUKHMODOVYM REZONATOROM].

L. A. Ostrovskii (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorki, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 49, Nov. 1965, p. 1535-1543. 6 refs. In Russian.

Discussion of the oscillations of a laser with a resonator having two modes slightly differing in frequencies. Possible monochromatic processes, their transformations, and the nonlinear fluctuations in oscillation intensity are considered. The form and amplitude of the oscillation peaks are determined. It is noted that the phase space in the averaged equations of the laser optical system contains a stable limiting cycle, which suggests that oscillations in such systems may become nonattenuating. V. Z.

**A66-16944 #**

SOME LASER INTERFEROMETERS FOR USE IN FLUID MECHANICS. L. H. Tanner (Belfast, Queen's University, Belfast, Northern Ireland).

*Journal of Scientific Instruments*, vol. 42, Dec. 1965, p. 834-837. 13 refs.

Discussion of the advantages of gas lasers as light sources in interferometers intended for use in aerodynamic research. It is shown that by using laser sources the restrictions on the design of an interferometer may be removed. Several appropriate interferometer designs, all of which depend for their success on the coherence of the laser light source, are discussed. The results of experiments with these different types of interferometers are evaluated. A. B. K.

**A66-17026**

TECHNOLOGY AND PROPERTIES OF INDIUM ARSENIDE LASERS [TECHNOLOGIE ET PROPRIETES DES LASERS A ARSENIURE D'INDIUM].

M. Rodot, P. Leroux-Hugon (Centre National de la Recherche Scientifique, Laboratoire de Magnétisme et de Physique du Solide, Bellevue, Seine-et-Oise, France), J. Besson, and H. Lebloch (Société Anonyme de Télécommunications, Paris, France).

*L'Onde Electrique*, vol. 45, Oct. 1965, p. 1197-1203. 7 refs. In French.

Research supported by the Direction des Recherches et Moyens d'Essais.

Discussion of the phenomenon of stimulated emission in indium arsenide, where it was found that the excitation threshold of the laser effect is particularly low and that the emission of light is highly directional. The laser functioned continuously at 27°K. The population inversion was obtained by carrier injection through a p-n junction, and the parameters affecting diffusion are discussed. Several Fabry-Pérot modes appeared on the spectral energy distribution. Various practical applications are pointed out, such as optical excitation experiments with semiconductors, and measurement of the time constant of IR detectors. F. R. L.

**A66-17040 #**

MECHANISM OF GAS BREAKDOWN BY LASERS.

P. F. Browne (Westinghouse Electric Corp., Research Laboratories, Pittsburgh, Pa.).

*Physical Society, Proceedings*, vol. 86, Dec. 1965, p. 1323-1332. 19 refs.

Contract No. AF 30(602)-3332.

Demonstration that microwave breakdown theory and inverse bremsstrahlung are the classical and quantum descriptions of one and the same process. In the cases of both microwave and laser breakdowns an electron oscillating in the threshold field for breakdown experiences a change of energy of about  $10^{-2}$  ev at a collision when the phase of its oscillatory velocity changes relative to that of the field. The classical (microwave) theory of breakdown and the free-free absorption are discussed. The absorption of radiation in the focal volume where a laser pulse is concentrated in a gas is considered. The neglect of losses due to diffusion and recombination is discussed, and it is shown that the atom or positive ion gas will come to thermal equilibrium with the electron gas only after the cascade ionization is complete. M. F.

**A66-17064**

NONLOCALIZED INTERFERENCE RINGS OBSERVABLE IN THE VICINITY OF A BEAM EMITTED BY A GAS LASER [ANNEAUX D'INTERFERENCE NON LOCALISES, OBSERVABLES AU VOISINAGE DU FAISCEAU EMIS PAR UN LASER A GAZ].

Guy Mas and Jean Roig (Montpellier, Université, Laboratoire d'Optique Physique, Montpellier, France).

*Académie des Sciences (Paris), Comptes Rendus*, vol. 261, no. 21, Nov. 22, 1965, p. 4348-4351. In French.

Use of a sealed helium-neon tube placed between two exterior mirrors to investigate the serrated system of rings found to surround the central beam, which itself was surrounded by a wide system of rings. This is a classical interference phenomenon attributable to the successive reflections on the two faces of the plane-concave mirror, of which the spherical surface constitutes the terminal mirror of the laser. F. R. L.

**A66-17065**

MULTIPHOTONIC PROCESSES IN DIELECTRICS [PROCESSUS MULTIPHOTONIQUES DANS LES DIELECTRIQUES].

Francis Floux, Pierre Nelson and Pierre Veyrie (Commissariat à l'Energie Atomique, Centre d'Etudes de Limeil, Service Documentation, Villeneuve-Saint-Georges, Seine-et-Oise, France).

*Académie des Sciences (Paris), Comptes Rendus*, vol. 261, no. 21, Nov. 22, 1965, p. 4366-4368. 8 refs. In French.

Extension of the concept of ionization under laser action to the cases of metals and dielectrics. The thresholds become very high in the case of metals, and relatively weak in the case of dielectrics. Experimental verification was obtained. The destructive phenomena observed in lasers of a certain power are attributed to the appearance of this ionization. F. R. L.

**A66-17104 #**

CONVENTIONAL FLOW VISUALIZATION USING LASER LIGHT SOURCE.

Raymond Sedney, Robert L. Rowe, Clarence C. Bush, and Leonard E. Voelker (U.S. Army, Ballistic Research Laboratories, Aberdeen Proving Ground, Md.).

*American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-127*. 16 p. 13 refs.

Members, \$0.50; nonmembers, \$1.00.

The purpose of this paper is to illustrate and discuss the potential uses of laser light sources in the conventional means of flow visualization. In the experiments described a CW gas laser was used. The properties of the laser that are exploited are: coherence, monochromaticity and small beam divergence. Some preliminary results of schlieren studies are given. Shadowgraphs show sharp diffraction patterns at the body surface and quite distinct interference fringes behind the shock shadow. A method of analyzing these fringes to obtain data on density behind the shock is indicated. An interferometer using only one wedge plate is described which is simple to set up and adjust. A schlieren system can be easily modified to incorporate this interferometer. The principle of this interferometer requires the large coherence length of a laser source. A number of examples of interferograms taken by this technique are shown. Some speculations will be advanced on the possibility of obtaining flow holograms for three-dimensional flow visualization. (Author)

**A66-17205****SOME PHOTOGRAPHIC STUDIES OF THE LIGHT OUTPUT OF AN INTRACAVITY-MODULATED GAS MASER.**

L. E. Hargrove and J. S. Courtney-Pratt (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

*SMPE, Journal*, vol. 74, Dec. 1965, p. 1085-1095. 10 refs.

Using a high-speed rotating mirror to sweep the image, the light output from a helium-neon gas maser was photographed with and without intracavity modulation at the locking frequency  $f_0$ , which corresponds to the reciprocal of the round-trip travel time for light within the maser, and which also equals the cavity mode spacing. When the maser was locked, the photographic record showed regular pulses. The light level was 1,500 times the minimum required to record individual dots. When the maser was not locked, the photographs showed beats at harmonics of the mode spacing. The amplitudes of the beat frequencies varied most irregularly from moment to moment, sometimes changing noticeably in less than half a microsecond and radically in less than a millisecond. No evidence was found of reciprocity failure for Eastman Kodak Type IF emulsion to the accuracy of the energy measurements (i.e., to a factor of 2 up or down from the mean), for exposure times from 1 nanosec to 30 sec. (Author)

**A66-17217****REJECTION OF COHERENT INTERFERENCE IN OPTICAL MODULATION-DEMODULATION EXPERIMENTS.**

J. Richard Kerr (Sylvania Electric Products, Inc., Sylvania Electronic Systems Div., Electronic Defense Laboratories, Optics Dept., Mountain View, Calif.).

*IEEE Transactions on Instrumentation and Measurement*, vol. IM-14, Dec. 1965, p. 209-214. 5 refs.

Contract No. DA-36-039-AMC-00094(E).

Systems are described which reject both coherent interference (modulator-leakage pickup) and noise in laboratory modulation-demodulation systems, such as those used in microwave laser-communications experiments. The approach involves the use of audio-rate chopping and phase sensitive detection along with zero-IF or homodyne detection. Using these techniques, it is possible to make quantitative measurements of desired signals which have amplitudes several orders of magnitude smaller than coherently related interference signals, while rejecting both chopped and unchopped noise. Calibration techniques are discussed, and experiments are described which verify the operations of these systems. (Author)

**A66-17287****A LASER OUTPUT COUPLER USING FRUSTRATED TOTAL INTERNAL REFLECTION.**

Earl L. Steele, Walter C. Davis, and Robert L. Treuthart (North American Aviation, Inc., Autonetics Div., Lasers and Electro-Optics Dept., Anaheim, Calif.).

*Applied Optics*, vol. 5, Jan. 1966, p. 5-8. 5 refs.

A unique component has been developed, constructed, and incorporated into an optically pumped ruby laser system. Without using thin film optical coatings, this component allows a known fraction of the radiation to be coupled from a laser system while simultaneously serving as the partial reflector at the output end of the laser. The output coupler, herein described, utilizes a frustrated total internal reflection configuration and is fabricated of fused silica with an air gap  $0.48\mu$  in thickness as the critically controlled element. Techniques have been developed for establishing and maintaining the spacing of the silica members to a predetermined fraction of the ruby emission wavelength of  $6943\text{\AA}$ . The measured transmission, reflection, and scattering loss characteristics of the coupler are discussed. In addition, schematic diagrams and photographs of the operating coupler are shown. This coupler has withstood repeated Q-spoiled bursts of laser radiation without damage. However, equivalent radiation pulses have consistently destroyed dielectric reflectors. Thus, more reproducible laser experiments can be performed with this coupler than with conventional optically coated reflectors. (Author)

**A66-17291****FREQUENCY CONTROL OF A  $\text{Nd}^{3+}$  GLASS LASER.**

Elias Snitzer (American Optical Co., Southbridge, Mass.).

*Applied Optics*, vol. 5, Jan. 1966, p. 121-125. 5 refs.

Army-supported research.

Discussion of the results of experiments on line narrowing of a neodymium glass laser with a reflection filter, a transmission filter, or both. It is found that laser emission can be obtained in narrow lines less than  $0.1\text{\AA}$  wide anywhere within a  $130\text{-\AA}$  interval centered about the peak emission at  $1.06\mu$  by the use of thin reflecting plates acting as wave-length-sensitive mode selectors. For a plate aligned perpendicular to the axis of the laser, the emission is at those wavelengths at which the plate thickness is an odd number of quarter wavelengths. The plate tends to produce a spiking emission as a function of time and no loss in output energy. M.M.

**A66-17292****THE EFFECT OF AXIAL MAGNETIC FIELDS ON GAS LASERS.**

Alan Corney (National Bureau of Standards and Colorado, University, Joint Institute for Laboratory Astrophysics, Boulder, Colo.).

*Applied Optics*, vol. 5, Jan. 1966, p. 127-130. 11 refs.

ARPA-supported research.

An expression is obtained for the intensity of polarized light transmitted through a laser amplifier and linear polarizer, as a function of the strength of an axial magnetic field. The result is compared with an experiment reported by Hotz in which it was claimed that the natural width of the laser transition was measured. The effect of applying a magnetic field parallel to the axis of a laser having plane-parallel windows is also considered. The variation in the frequency of beats between oppositely circularly polarized modes, as a function of magnetic field, is obtained. The result shows that an experiment performed by Culshaw and Kannelaud cannot be interpreted as a level-crossing effect as was previously supposed. (Author)

**A66-17293****A RECORDING SAMPLING SYSTEM FOR MEASURING LASER ENERGY.**

R. C. Williams and Harold A. Mueller (Virginia, Medical College, Dept. of Biophysics, Richmond, Va.).

*Applied Optics*, vol. 5, Jan. 1966, p. 135-138.

Research supported by the Defense Atomic Support Agency and Army.

An apparatus has been designed and built which simultaneously measures the energy incident on a biological system which is being exposed to a laser beam. The advantages of the direct reading system are: (1) no attention is required of the laser operator, (2) a permanent record is produced, (3) true integration of the pulse train is accomplished, (4) high inherent accuracy, (5) in conjunction with a fast oscilloscope, it reproduces pulse waveforms with minimum distortion, and (6) calibration is simple and direct. Basically the system employs a fast high-current capability photodiode, a high-quality integrating capacitor, an emission-limited pump diode with a servo-motor amplifier combination for dark current balance. The photodiode cathode surface is S-1 so that both ruby and neodymium wavelengths  $694.3\text{ m}\mu$  and  $1060\text{ m}\mu$ , respectively, may be measured. Reproducibility is better than 3% when compared with a blackbody receiver (cone radiometer). A Tektronix 585A oscilloscope and P-80 cathode follower probe fitted with a  $50\text{-}\Omega$  load resistor can be plugged into the photodiode housing in place of the integrating capacitor for waveform observation and power-level measurements. Calibration on an absolute basis is easily accomplished by simultaneous comparison with a calibrated blackbody receiver (cone radiometer). (Author)

**A66-17294****CONSIDERATION OF ATMOSPHERIC TURBULENCE IN LASER SYSTEMS DESIGN.**

J. I. Davis (Hughes Aircraft Co., Aerospace Group, Culver City, Calif.).

(Conference on Atmospheric Limitations to Optical Propagation, Boulder, Colo., Mar. 17, 1965, Paper.)

*Applied Optics*, vol. 5, Jan. 1966, p. 139-147. 17 refs.

The physical basis for various effects of atmospheric turbulence on laser systems is briefly discussed, and certain limitations of the theoretical results given by Tatarski are summarized. The most important conclusion is that Tatarski's results for amplitude and phase fluctuations, while they are not applicable for a laser beam of arbitrary diameter, do provide an adequate approximation when the beam diameter is at least a factor of 2 greater than the lateral correlation length for amplitude fluctuations, which is true in many applications. The effects analyzed in some detail are beam steering, beam spreading, image dancing, image blurring, scintillation, and phase fluctuations, certain of which are intimately related. As to specific applications, the signal-to-noise ratio for an AM signal passing through the turbulent atmosphere is derived in terms of the power fluctuation, and communication links are considered in terms of this ratio; the effect of power fluctuations on the probability of detection for the laser radar is discussed in general, and a special example is given; finally, the spot size on the moon's surface for a transmitter located on the earth's surface is calculated for different turbulence conditions. (Author)

#### A66-17295

##### THE ABSORPTION OF LASER RADIATION ALONG ATMOSPHERIC SLANT PATHS.

Gilbert N. Plass (Southwest Center for Advanced Studies, Dallas, Tex.).

*Applied Optics*, vol. 5, Jan. 1966, p. 149-154. 15 refs. USAF-NASA-supported research.

The absorption of laser radiation along atmospheric slant paths is calculated when Lambert's law is valid. Illustrative results are given for absorbing gases which are distributed uniformly throughout the atmosphere and when the temperature variation of the line intensities and half-width can be neglected. These results are then generalized to include cases of nonuniformly distributed gases with a temperature variation along the path. The effect of the overlapping of spectral lines is studied through the use of the Elsasser model. Finally, it is shown that large differences in the absorbance may occur between corresponding frequencies in the red and violet wings when there is a shift in the position of the line center with pressure. This line shift could ideally be studied with laser sources. (Author)

#### A66-17297

##### SYNCHRONIZATION OF SEVERAL Q-SWITCHED OPTICAL MASERS.

Nguyen van Tran and D. Kehl (Compagnie Générale d'Electricité de Paris, Centre de Recherches, Département Recherches Physiques de Base, Marcoussis, Seine-et-Oise, France).

*Applied Optics*, vol. 5, Jan. 1966, p. 168, 169.

Description of a scheme used to synchronize a Q-switched ruby laser with a neodymium-doped glass Q-switched laser. The experimental setup includes a totally reflecting prism rotating at 24,000 rpm, a flat mirror with a multielectric coating for maximum reflection at 6943 Å, and two flat mirrors with different reflection coefficients. The two lasers are Q-switched by the same rotating prism. The two (helical) flashtubes are triggered independently, with proper delay time from the same reference signal generated in a coil linked with the rotating prism. The synchronization is obtained by means of a slight rotation of the first mirror around an axis parallel to the axis of rotation of the rotating prism. Oscillograms recorded from a double-beam model 555 Tektronix oscilloscope are shown. M.M.

#### A66-17329

##### MODE CONTROL IN p-n JUNCTION LASERS.

D. K. Wilson (Bell Telephone Laboratories, Inc., Whippany, N.J.).

IN: RADIATIVE RECOMBINATION IN SEMICONDUCTORS; INTERNATIONAL CONFERENCE ON THE PHYSICS OF SEMICONDUCTORS, 7TH, PARIS, FRANCE, JULY 27, 28, 1964, PROCEEDINGS. VOLUME 4. [A66-17310 07-26]

Conference sponsored by the International Union of Pure and Applied Physics, the United Nations Educational, Scientific and M. H. Pilkuhn and H. Rupprecht (International Business Machines Corp., Thomas J. Watson Research Center, Yorktown Heights, N. Y.).

IN: RADIATIVE RECOMBINATION IN SEMICONDUCTORS; INTERNATIONAL CONFERENCE ON THE PHYSICS OF SEMICONDUCTORS, 7TH, PARIS, FRANCE, JULY 27, 28, 1964, PROCEEDINGS. VOLUME 4. [A66-17310 07-26]

Conference sponsored by the International Union of Pure and Applied Physics, the United Nations Educational, Scientific and Cultural Organization, and the International Atomic Energy Agency. New York, Academic Press, Inc., 1965, p. 195-199; Discussion, M. Gershenzon and C. H. Gooch, p. 199. 5 refs. DOD-ARPA-Navy-supported research.

Experimental results concerning gain and losses in GaAs lasers, obtained by varying the laser length. The temperature dependence of loss and gain factor of GaAs diodes, the temperature dependence of the threshold current density of GaAs lasers with different substrate doping levels, and the junction luminescence of GaAs with a small background doping of copper are graphed. For comparison, p-n junctions were prepared by copper diffusion into n-type GaAs, making copper the only acceptor present. In this case, the external quantum efficiency of the spontaneous emission was measured to be  $2 \times 10^{-4}$  at 77°K. This is about one hundredth of the value found for the spontaneous emission of laser-type diodes at that temperature. M.F.

#### A66-17333

##### TEMPERATURE DEPENDENCE OF EMISSION SPECTRUM AND THRESHOLD CURRENT IN GaAs LASERS.

J. I. Pankove (Radio Corporation of America, RCA Laboratories, Princeton, N.J.).

IN: RADIATIVE RECOMBINATION IN SEMICONDUCTORS; INTERNATIONAL CONFERENCE ON THE PHYSICS OF SEMICONDUCTORS, 7TH, PARIS, FRANCE, JULY 27, 28, 1964, PROCEEDINGS. VOLUME 4. [A66-17310 07-26]

Conference sponsored by the International Union of Pure and Applied Physics, the United Nations Educational, Scientific and Cultural Organization, and the International Atomic Energy Agency. New York, Academic Press, Inc., 1965, p. 201-203; Discussion, J. Franks and W. N. Carr, p. 204. 9 refs.

Measurement of the emission spectrum and the threshold current of a GaAs injection laser at various temperatures from 4.2°K to room temperature. A direct method for assessing the relative distributions of carriers in the junction is the measurement of the emission spectrum. Such a study reveals that the emission peak near threshold and the laser peak at threshold follow closely the temperature dependence of the energy gap, differing from the energy gap of pure GaAs by at least 30 Mev. It was discovered that the threshold current, in nearly all the lasers measured, varies exponentially with temperature. The slope of this exponential dependence varies with the processing of the p-n junction. It is found that the spontaneous emission varies nearly as the square of the current at low temperatures, but becomes linear with current at room temperature. M.F.

#### A66-17337

##### EXCITATION OF SEMICONDUCTOR LASERS BY A BEAM OF FAST ELECTRONS.

N. G. Basov, O. V. Bogdankevich, and A. G. Deviatkov (Academy of Sciences, Physics Institute, Moscow, USSR).

IN: RADIATIVE RECOMBINATION IN SEMICONDUCTORS; INTERNATIONAL CONFERENCE ON THE PHYSICS OF SEMICONDUCTORS, 7TH, PARIS, FRANCE, JULY 27, 28, 1964, PROCEEDINGS. VOLUME 4. [A66-17310 07-26]

Conference sponsored by the International Union of Pure and Applied Physics, the United Nations Educational, Scientific and Cultural Organization, and the International Atomic Energy Agency. New York, Academic Press, Inc., 1965, p. 225-232; Discussion, p. 232, 233. 21 refs.

Investigation of the techniques and advantages of exciting semiconductor lasers with a beam of fast electrons. The works of Shockley, Popov, Keldysh, and Krokhin are briefly discussed.

Laser action by electron beam excitation was first observed in 1964 in the CdS crystal. A single crystal having the dimensions  $3 \times 2 \times 1.5$  mm was soldered to a piece of copper with Wood's alloy and was placed in the vacuum chamber of a helium cryostat. At large current densities, three narrow lines with wavelengths of 5036, 4966, and 4891 Å were observed. M. F.

#### A66-17453

EXPERIMENTAL VERIFICATION OF THE PHASE INVERSION BETWEEN TWO LOBES OF A LASER IN THE TEM<sub>10</sub> MODE [UNE VERIFICATION EXPERIMENTALE DE L'INVERSION DE PHASE ENTRE LES DEUX LOBES DU MODE TEM<sub>10</sub> D'UN LASER]. Gianenrico E. Frigerio and Alberto Sona (Milan, Université, Institut de Physique, Laboratoire Didactique, Milan, Italy). *Académie des Sciences (Paris), Comptes Rendus*, vol. 261, no. 23, Dec. 8, 1965, p. 5049-5051. In French.

Study of the system of fringes which result from placing two slits in two lobes in the TEM<sub>10</sub> mode of a laser. The study was based on the theory that there is a 180° phase change when the vector of an electric field E varies between two consecutive maxima. A He-Ne gas laser which emitted at 6328 Å was used. A formula is presented for expressing the distribution of the intensity of the fringe systems obtained with a double slit, assuming that the modulation due to refraction phenomena can be neglected. The experimental results confirmed that the phase change of the vectors which represent the amplitude of the field within the lobes is equal to 180°. D. P. F.

#### A66-17473

STUDY OF LIGHT SCATTERING BY NONABSORBING SPHERICAL PARTICLES NEAR THE BOUNDARY OF GEOMETRICAL OPTICS [UNTERSUCHUNGEN ZUR LICHTSTREUUNG AN ABSORPTIONS-FREIEN KUGELFÖRMIGEN EINZELTEILCHEN IM GRENZBEREICH DER GEOMETRISCHEN OPTIK]. J. Gebhart and H. Straubel (Battelle-Institut, Frankfurt am Main, West Germany). *Zeitschrift für angewandte Physik*, vol. 20, no. 2, 1965, p. 145-149. 7 refs. In German.

Investigation of laser-beam scattering by individually introduced charged polystyrene spheres and droplets of naphthalene and water in combination. The particles, 50 to 130 μ in diameter, were suspended at rest in a capacitor with an annular diaphragm. The experimental technique is described and the light scattering effect, similar to that observed previously by the authors on transparent glass filaments, is shown in diffraction-pattern photographs. The characteristic rings in the photographs are believed to result from the interference of refracted and reflected light. The behavior of the interference and diffraction minima when the particle radius decreases is considered in the light of the Mie theory of wave optics. V. Z.

#### A66-17532 #

THE CHARACTER OF OSCILLATION SPIKES DURING QUASI-CONTINUOUS OPERATION OF A RUBY LASER. T. Daříček, K. Hamal, A. Novotný, and V. Sochor (Prague, Technical University, Faculty of Technical and Nuclear Physics, Prague, Czechoslovakia). *Czechoslovak Journal of Physics, Series B*, vol. 15, no. 12, 1965, p. 933-936. 12 refs.

Quasi-continuous operation of a ruby laser at room temperature was performed with a crystal placed in the spherical cavity with threshold energy of 48 joules. The duration of the impulse of stimulated emission was 2700 μsec. The character of the spikes was observed and it was found that it is far from sinusoidal. The results of threshold energy measurements for other pumping configurations are discussed and compared with those obtained by other authors. (Author)

#### A66-17623

FREQUENCY-PULLING BAND OF A LASER OSCILLATOR. I. L. Bershtein (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR). (*Akademiia Nauk SSSR, Doklady*, vol. 163, July 1, 1965, p. 60-62.) *Soviet Physics - Doklady*, vol. 10, Jan. 1966, p. 607-609. Translation. [For abstract see issue 19, page 2818, Accession no. A65-30070]

#### A66-17626

EVALUATION OF ENERGY PARAMETERS IN THE LASER WELDING OF METALS. N. N. Rykalin and Iu. L. Krasulin (Akademiia Nauk SSSR, Institut Metallurgii, Moscow, USSR). (*Akademiia Nauk SSSR, Doklady*, vol. 163, July 1, 1965, p. 87-90.) *Soviet Physics - Doklady*, vol. 10, Jan. 1966, p. 659-661. 6 refs. Translation. [For abstract see issue 19, page 2815, Accession no. A65-30071]

#### A66-17816

SCATTERING OF LASER PHOTONS ON FAST ELECTRONS [STREUUNG VON LASERPHOTONEN AN SCHNELLEN ELEKTRO- NEN]. H. Krüger (Freiburg, Universität, Physikalisches Institut, Freiburg im Breisgau, West Germany). *Zeitschrift für Physik*, vol. 189, no. 3, 1966, p. 302-311. In German. Discussion of Compton scattering of laser photons which are transformed into γ-radiation photons upon collision with high-energy electrons. Detailed calculations are given for the "average" polarization over the scattered beam and for the energy spectrum of the γ-rays, without analyzing the electron polarization. The energy distribution of the scattered photons, integrated over the azimuth, is determined, without taking the photon polarization into account. A. B. K.

#### A66-17817

QUANTUM-MECHANICAL TREATMENT OF THE OPTICAL MASER [QUANTENMECHANISCHE BEHANDLUNG DES OPTISCHEN MASERS]. Herwig Sauermann (Stuttgart, Technische Hochschule, Institut für theoretische und angewandte Physik, Stuttgart, West Germany). *Zeitschrift für Physik*, vol. 189, no. 3, 1966, p. 312-334. 24 refs. In German.

Quantum-mechanical treatment of the self-sustained oscillation of one mode in a solid-state laser system in which the active atoms decay not only by induced and spontaneous emission into the lasing mode, but also by spontaneous emission into the continuum of non-lasing modes. A coupled nonlinear system of equations for the atomic and oscillation operators is derived with the aid of the Heisenberg picture, and the most important properties of the fluctuation operators are given. This system of equations is then linearized, and the behavior of the oscillation in the linear region below the threshold of laser activity is investigated. It is shown that the line width of the oscillation decreases with increasing pumping power and that the line photon number has a Gaussian distribution. Finally, the nonlinear behavior of the oscillation above the threshold is investigated in the steady state. The laser line is shown to grow out of a broad background of spontaneous-emission noise. A. B. K.

#### A66-17877 #

GENERATION OF INDUCED RADIATION IN PRESTATIONARY REGIME [GENERATSIIA INDUKOVANOGO VIPROMINUVANNIA U PEREDSTATSIONARNOMU REZHIMI]. B. L. Līvshits' and V. M. Tsikunov (Akademiia Nauk SSSR, Institut Zagal'noi ta Neorganichnoi Khimii, Moscow, USSR). (*Ukrains'kii Fizicheskii Zhurnal*, vol. 10, Nov. 1965, p. 1267-1270. In Ukrainian.

Brief discussion of the transition of a laser to a stationary regime of operation. A system of two equations describing the laser operation mode before the onset of a stationary regime are solved. V. Z.

#### A66-18035

LASER EMISSION IN IONIZED MERCURY - ISOTOPE SHIFT, LINEWIDTH, AND PRECISE WAVELENGTH. R. L. Byer, W. E. Bell, E. Hodges, and A. L. Bloom (Spectra-Physics, Inc., Mountain View, Calif.). *Optical Society of America, Journal*, vol. 55, Dec. 1965, p. 1598-1602. 15 refs. Army-supported research.

## A66-18153

The 6150-Å laser transition in Hg II generated in a pulsed hollow cathode discharge, has been studied under high resolution. The line shows structure corresponding to the expected shifts from the even isotopes, with a spacing of approximately 26.5 mK (800 Mc/sec) between adjacent components, in rough agreement with earlier results. The fullwidth at half-maximum of each component has been measured as 500 Mc/sec. The wavelength has been compared to that of thorium secondary wavelength standards and it has been determined that the vacuum wavelength of the  $^{202}\text{Hg}$  component is 6151.1650 Å. The possibility of the mercury hollow cathode laser as a laboratory wavelength standard is pointed out. (Author)

## A66-18153 #

THEORY AND APPLICATION OF PULSED LASER WELDING. J. E. Anderson (Union Carbide Corp., Linde Div., Development Laboratory, Newark, N. J.) and J. E. Jackson (Union Carbide Corp., Linde Div., Research Laboratory, Speedway, Ind.). (American Welding Society, National Fall Meeting, Birmingham, Ala., Oct. 4-7, 1965, Paper.)

Welding Journal, vol. 44, Dec. 1965, p. 1018-1026.

Evaluation of pulsed laser welding and description of some specific applications. It is noted that the theory of the effects of a high-intensity pulsed heat source on a metal surface is reasonably well understood. This is backed up by an extensive experimental study of pulsed laser welding of wire and sheet, including practical applications. The basic advantages and limitations of the process are discussed in the light of the latest experimental data. M. M.

## A66-18257 #

CONCENTRATION AND TEMPERATURE DEPENDENCE OF SPIN-LATTICE RELAXATION TIME IN RUBY AT HELIUM TEMPERATURES. RELAXATION IN A ZERO MAGNETIC FIELD [KON-TSENTRATSIONNAIA I TEMPERATURNAYA ZAVISIMOSTI VREMEN SPIN-RESHETOCHNOI RELAKSATsii V RUBINE PRI GELEVIYKH TEMPERATURAKH - RELAKSATsiiA V NULEVOM MAGNITNOM POLE].

A. A. Manenkov and Iu. K. Danileiko (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). ZHETF Pis'ma v Redaktsiiu, vol. 2, Nov. 1, 1965, p. 414-418. 11 refs. In Russian.

Measurements at 1.6 to 4.2°K of the spin-lattice relaxation time ( $T_1$ ) of ruby samples with 0.05 to 0.7% of  $\text{Cr}^{3+}$  ion, grown by the Verneuil method in a highly reducing medium. The measurements were made in order to verify the contradictory results of other authors on the existence in such crystals of a dependence of  $T_1$  on the concentration of  $\text{Cr}^{3+}$ .  $T_1$  is determined at 11, 472 and 9400 Mc by pulse saturation of the PMR lines, proving the existence of a temperature dependence of  $T_1$  that obeys the law  $T_1 \sim T^{-1}$  at these temperatures and concentrations of  $\text{Cr}^{3+}$  ions. V. Z.

## A66-18333

A LASER VELOCIMETER.

Gus Stavis (General Precision, Inc., General Precision Aerospace Group, GPL Div., Pleasantville, N. Y.). TNB General Precision Aerospace, vol. 8, 4th Quarter, 1965, p. 20-25, 6 refs.

Description of a new diffraction velocimeter which has the capability of detecting and measuring the transverse movement of a surface by appropriately sensing the light backscattered by it when illuminated by a laser. The characteristics of the backscattered light pattern which permit the precise measurement of velocity and displacement of a diffuse surface are discussed; it is shown that the rate of pattern motion is linearly related to the relative speed between source and the diffuse surface giving rise to the pattern. The explanation for the regular motion of random reflected pattern is given in terms of a model which considers only two scatterers within the beam. The parameters of the backscattered pattern and the basic design of the velocimeter are described. Applications such as a capability for precise distance measurement over terrain are discussed. D. P. F.

## A66-18354

ELECTRON ENERGY SPECTRA IN NEON, XENON, AND HELIUM-NEON LASER DISCHARGES.

J. Y. Wada and Hans Heil (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

IEEE Journal of Quantum Electronics, vol. QE-1, Nov. 1965, p. 327-335, 21 refs.

Absolute measurements of the electron energy spectrum in a helium-neon mixture and in pure neon and xenon have been obtained by an energy analysis of a sample of electrons extracted through a small hole in the anode. The spectrum appears to be nearly Maxwellian for the lower pressures but deviates markedly from a Maxwellian at higher pressures. At higher pressures, the energetic part of the spectrum drops off faster, and one can describe this part by a Maxwellian of lower temperature than that for the bulk of the distribution. The average energies agree with those obtained from microwave measurements of the radiation temperature of the electrons if corrections are made for nonthermal distribution. Several production rates are computed with the help of the measured spectra, and they are related to the wall current, the power dissipation, and the possible electron depopulation of helium metastables. The production and destruction rates for the different parts of the energy spectrum have been formulated mathematically. A theoretical formula, which describes the actual spectra, has been derived for the faster part of the spectrum. For the helium-neon laser discharge we can say definitely that the deexcitation of helium metastables by electrons is negligible. (Author)

## A66-18355

DIRECT MODULATION OF GAS LASERS.

Teiji Uchida (Nippon Electric Co., Ltd., Radio Industry Div., Tokyo, Japan).

IEEE Journal of Quantum Electronics, vol. QE-1, Nov. 1965, p. 336-343, 18 refs.

Direct modulation of gas lasers such as internal modulation, coupling modulation, and phase locking, has been investigated in a 6328 Å He-Ne laser containing a composite modulation element with small insertion loss. It was verified theoretically and experimentally concerning internal modulation that the bandwidth of gas lasers for small perturbation of resonator loss decreases with an increase of resonator loss contrary to the passive circuit case and depends on the dynamic Q of the gas laser as an active tuned circuit rather than the resonator Q. The measured bandwidth of 6328 Å He-Ne lasers was about 1 Mc. Coupling modulation has a flat frequency response above the bandwidth of gas lasers except in the vicinity of harmonics of  $c/2L$ . Forced phase locking by the frequency  $c/2L$  is necessary to realize the stable low noise operation of gas lasers. The modulation method simultaneously using the composite modulation element as coupling modulation element and phase-locking element ensures a signal transmission of good quality in optical communications. (Author)

## A66-18356

STABILIZED, SINGLE-FREQUENCY OUTPUT FROM A LONG LASER CAVITY.

P. W. Smith (Bell Telephone Laboratories, Inc., Holmdel, N. J.). (Institute of Electrical and Electronics Engineers, Electron Device Research Conference, Urbana, Ill., June 23-25, 1965, Paper.)

IEEE Journal of Quantum Electronics, vol. QE-1, Nov. 1965, p. 343-348, 21 refs.

The problem of obtaining single-frequency output from a long laser is considered, and two methods are investigated experimentally. The first method consists of using an external filter to select one of a number of oscillating modes. The second method consists of suppressing internally the unwanted resonances so that the laser oscillation can only take place at a single frequency. It is shown that with the second method one can in many cases obtain greater power, and experiments are reported in which single-frequency output power of 15 mw was obtained from a 6328 Å He-Ne laser. A simple feedback circuit is described for stabilizing the frequency of the laser oscillation. (Author)

## A66-18357

FREQUENCY STABILIZATION OF GAS LASERS.

A. D. White (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).

IEEE Journal of Quantum Electronics, vol. QE-1, Nov. 1965, p. 349-357, 23 refs.

The state of the art in the field of frequency stabilization of gas lasers is surveyed. A brief discussion of the methods employed to determine the frequency stability of lasers is followed by a listing of the principle causes of frequency instability. The close relationship existing between the control system design and the laser environment is pointed out. Stabilization techniques based on the use of atomic resonance and on the use of interferometers are discussed in detail. Many of these techniques are capable of achieving long-term frequency stabilities of one part in  $10^9$  or better, which appears to be entirely adequate for most systems applications.

(Author)

#### A66-18358

##### TIME RESOLUTION OF LASER INDUCED ELECTRON AND ION EMISSION.

S. H. Khan, F. A. Richards, and D. Walsh (Oxford, University, Engineering Science Dept., Oxford, England).  
*IEEE Journal of Quantum Electronics*, vol. QE-1, Nov. 1965, p. 359, 360.

Research supported by the Science Research Council; Grant No. AF EOAR 65-37.

Investigation of the emission produced by a Q-switched laser pulse focused onto a clean flat metal surface. The active laser element was a  $2 \times 1/4$  in. ruby crystal. It was Q-switched by means of a mirror rotating at 12,000 rpm. The maximum laser energies were approximately 50 mJoules, as measured by a carbon cone calorimeter. The time duration of the pulse, measured at half-power points, was 75 nsec. For a laser input of this order, and using both tantalum and niobium-tin alloy targets the electron emission was found to form two main peaks. It is considered that the first electron emission peak is probably due to normal thermionic emission; the second and larger electron and ion pulses may be due to vaporization also. When the surface vaporizes, considerable numbers of ions and electrons are formed by collision processes in the hot, dense vapor. The dispersion of these charged particles to the electrode of opposite sign may thus cause the second electron and ion emission pulse.

F. R. L.

#### A66-18359

##### COMMUNICATION BY LASER.

Stewart E. Miller (Bell Telephone Laboratories, Inc., Research Communications Systems Div., Guided Wave Research Laboratory, Holmdel, N. J.).

*Scientific American*, vol. 214, Jan. 1966, p. 19-27.

Nontechnical discussion of the possibilities of using lasers for long-distance communication of electrical signals. The basic principles of long-distance transmission of large amounts of information are described. The four multiplexed systems currently available - coaxial cable, microwave, waveguide, and relay satellite - are considered. Oscillation, modulation, and transmission problems of long-distance laser communication are discussed.

R. A. F.

#### A66-18361

##### THEORY OF LASER EMISSION ASSOCIATED WITH INDIRECT BAND-TO-BAND TRANSITIONS.

V. S. Mashkevich and V. L. Vinetaki (Akademiia Nauk Ukrainskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR).

(*Fizika Tverdogo Tela*, vol. 7, July 1965, p. 1987-1993.)

*Soviet Physics - Solid State*, vol. 7, Jan. 1966, p. 1605-1609. Translation.

[For abstract see issue 20, page 2971, Accession no. A65-31884]

#### A66-18393

##### APPLICATION OF ELECTRON AND OPTICAL MICROSCOPY IN STUDYING LASER-IRRADIATED METAL SURFACES.

K. Vogel (Uppsala, Royal University, Institute of Physics, Uppsala, Sweden) and P. Backlund (Uppsala, Royal University, Institute of Chemistry, Uppsala, Sweden).

*Journal of Applied Physics*, vol. 36, Dec. 1965, p. 3697-3701. 13 refs.

Electron and optical microscopy were applied in studying laser-irradiated metal surfaces. The preparation of carbon replica films of irradiated surfaces is described. A summary of observations from irradiated Ag, Al, Be, Cu, Pb, and low-carbon steel is given. Microcraters of less than  $10 \mu$  diam were found to be an early stage in the development of radiation damage on laser-irradiated metal surfaces. The observed surface structure is assumed to be of interest when interpreting experiments on the interaction of laser beams with metal surfaces.

(Author)

#### A66-18397

##### BASIC EQUATIONS AND CONSERVATION THEOREMS FOR THE ELECTROSTRICTION PHONON MASER.

H. A. Haus and Paul Penfield, Jr. (Massachusetts Institute of Technology, Dept. of Electrical Engineering and Research Laboratory of Electronics, Cambridge, Mass.).

*Journal of Applied Physics*, vol. 36, Dec. 1965, p. 3735-3739. 19 refs.

Contract No. DA-36-039-AMC-03200(E).

Analysis of an exact set of equations for a lossless polarizable fluid, disregarding only relativistic effects. When these equations are linearized and higher order terms in the ratio of sound speed to light speed are disregarded, they reduce to the customary set of equations. The more exact equations permit the derivation of the law of the conservation of energy with a simple physical interpretation. From these equations the Manly-Rowe relations and other conservation laws also follow relatively easily.

B. B.

#### A66-18413

##### PHASE LOCKING OF MODES IN LASERS.

H. Stats and C. L. Tang (Raytheon Co., Research Div., Waltham, Mass.).

*Journal of Applied Physics*, vol. 36, Dec. 1965, p. 3923-3927. 19 refs.

Contract No. AF 19(628)-4981.

An investigation is made of the phase-locking effects in lasers. It is shown that the phases of the simultaneously oscillating modes of lasers are not independent variables as sometimes thought. The calculations have been limited to three modes and homogeneously broadened lines. It is found that the sum of the phases of the low- and high-frequency modes as measured relative to the phase of the center mode assumes a definite value, which depends in turn upon the location of the active medium within the cavity. This phase relationship has a profound effect on experiments conducted with multimode lasers. For example, it is found that there should be essentially no fundamental-frequency beat note as observed by a square-law detector when a small laser crystal is placed in the center of an optical cavity.

(Author)

#### A66-18418

##### EFFECT OF ORGANIC CATIONS ON THE LASER THRESHOLD OF SOLUTIONS OF EUROPIUM TETRAKIS BENZOYLTRIFLUORO-ACETONATE.

E. P. Riedel and R. G. Charles (Westinghouse Electric Corp., Research Laboratories, Pittsburgh, Pa.).

*Journal of Applied Physics*, vol. 36, Dec. 1965, p. 3954, 3955. 5 refs.

Contract No. Nonr-4573(00).

Experimental investigation of laser action on 15 organic salts of  $\text{Eu}(\text{BTF})_4$  in acetonitrile. Laser action was obtained for all but one of them. It is found that the stored electrical energy required to reach threshold oscillations in these solutions is dependent to a surprising degree on the nature of the organic cation. It is concluded that the cation in the salt  $\text{BEu}(\text{BTF})_4$  can be important in determining the laser capabilities of solutions containing the salt without interacting directly with the lasing species  $\text{Eu}(\text{BTF})_4$  to change its spectral properties.

M. M.

#### A66-18424

##### VIBRATIONAL-ROTATIONAL LASER ACTION IN CARBON MONOXIDE.

C. K. N. Patel (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).

*Physical Review, 2nd Series*, vol. 141, Jan. 1966, p. 71-83. 25 refs.

In this paper we give details of the laser action on rotational transitions of 10-9, 9-8, 8-7, 7-6, and 6-5 vibrational bands belonging to the ground electronic state ( $X^1\Sigma^+$ ) of CO. Laser action is produced in a low-pressure CO pulsed discharge. A comparison between the measured laser wavelengths (accuracy of  $\pm 0.5 \text{ \AA}$  at 5.0 to 5.4  $\mu$ ) and wavelengths calculated from available molecular constants of CO shows that a small correction in the vibrational constants may be necessary. A generalized treatment of optical gain on vibrational-rotational transitions is given and it is seen that it is advantageous to operate these lasers at as low a temperature as possible for production of maximum gain. An attempt is made to analyze the excitation mechanisms responsible for these laser transitions. It is seen that the excitation processes, under pulsed operation, have to be complicated and time-dependent in order to be able to duplicate theoretically the time dependence observed for the laser power output. It is shown that under the conditions of very selective excitation of a particular vibrational level, it should be possible to obtain CW laser oscillation on some P-branch vibrational-rotational transitions. (Author)

#### A66-18429

##### COHERENCE EFFECTS IN GASEOUS LASERS WITH AXIAL MAGNETIC FIELDS. I - THEORETICAL.

W. Culshaw and J. Kannelaud (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Research Laboratories, Palo Alto, Calif.). *Physical Review, 2nd Series*, vol. 141, Jan. 1966, p. 228-236. 11 refs. Research supported by the Lockheed Independent Research Funds.

The Lamb theory of the optical maser is applied to circularly polarized atomic transitions, and used to consider the beat frequency and the coherence properties of such orthogonal fields when axial magnetic fields are applied to the gaseous laser. The beat frequency approaches zero in near-zero magnetic fields and synchronization can then occur between the right- and left-handed circularly polarized oscillations. For a resonator with no undue polarization constraint, such a strong coupling gives rise to a linearly polarized output, and to a rotation of the plane of polarization with increasing magnetic field. A self-consistent expression is derived for this rotation under steady-state conditions, and a maximum rotation of  $\pm 1/4\pi$  with magnetic field is indicated before the synchronization breaks down and circularly polarized beat phenomena appear. The rotation with magnetic field depends on the laser intensity, on the anisotropy in the cavity losses, and on the position of the cavity resonance within the Doppler linewidth. Also, the angle of rotation is indeterminate unless such anisotropy is present. Other regions of such coherence can occur at higher magnetic fields, where the beat frequency again approaches zero. These depend on the detailed shape of the various dispersion curves of the laser medium. The results derived from the theory used are in general agreement with experimental observations on the 1.53- $\mu$  He-Ne laser transition. (Author)

#### A66-18430

##### COHERENCE EFFECTS IN GASEOUS LASERS WITH AXIAL MAGNETIC FIELDS. II - EXPERIMENTAL.

J. Kannelaud and W. Culshaw (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Research Laboratories, Palo Alto, Calif.). *Physical Review, 2nd Series*, vol. 141, Jan. 1966, p. 237-245. 7 refs. Research supported by the Lockheed Independent Research Funds.

The rotation of the plane of polarization with an axial magnetic field on a short single-mode He-Ne planar-type laser has been studied experimentally. The study is concerned with regions of magnetic field where the beat frequency between the orthogonal circularly polarized oscillations approaches zero. A mutual synchronization of these otherwise independent oscillations then occurs over a range of magnetic field, resulting in a single frequency of oscillation in which the polarization remains linear but rotates. In near-zero magnetic field, rotations up to  $1/4\pi$  are observed and may occur with magnetic fields less than 0.1 gauss. Results are given on the rotation versus magnetic field as a function of the laser intensity, the cavity tuning within the Doppler linewidth, the total gas pressure, and the anisotropy in the cavity losses. The observed rotation increases with the intensity and decreases with cavity detuning, with increasing total gas pressure, and with increasing anisotropy in the cavity Q. On attaining a rotation of  $1/4\pi$ , a transition region of

magnetic field between the linear and circularly polarized regions is observed. The beat signal from the orthogonal circularly polarized waves then shows a high harmonic content due to transient behavior, which gives way to a single beat as the magnetic field is increased. Other such coherence regions are observed at magnetic fields of 10 gauss or more, where the observed beat frequency again approaches zero. Here the polarization again becomes linear and rotations similar to those in near-zero magnetic field are observed. (Author)

#### A66-18432

##### PHOTOCURRENT SPECTRUM AND PHOTOELECTRON COUNTS PRODUCED BY A GAS LASER.

Charles Freed (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.) and Hermann A. Haus (Massachusetts Institute of Technology, Dept. of Electrical Engineering and Research Laboratory of Electronics, Cambridge, Mass.). *Physical Review, 2nd Series*, vol. 141, Jan. 1966, p. 287-298. 21 refs.

Contract No. DA-36-039-AMC-03200(E).

The anode-current spectrum of a photomultiplier illuminated by light of time-varying intensity is obtained theoretically. The moments of the photoelectron counts under the same conditions are derived. The expressions are evaluated for the case of light emitted from a laser oscillator by using a semiclassical theory of the Van der Pol oscillator. The theoretical predictions are compared with experiments in which the spectrum of the photomultiplier was observed in the range 0-17 Mc and counts were recorded for counting intervals in the range between  $10^{-6}$  and  $10^{-1}$  sec. The three lowest-order factorial moments were evaluated as functions of T and compared with theory. The spectral data are used to predict the counting data and a comparison is made. The signal-to-noise ratio of the two types of experiments is evaluated and found to be comparable. (Author)

#### A66-18434

##### INTENSITY FLUCTUATIONS IN THE OUTPUT OF CW LASER OSCILLATORS. I.

D. E. McCumber (Bell Telephone Laboratories, Inc., Murray Hill, N. J.). *Physical Review, 2nd Series*, vol. 141, Jan. 1966, p. 306-322. 50 refs.

Using linearized rate equations, we have calculated the intensity fluctuations expected in the output of four-level cw laser oscillators. Intrinsic quantum effects have been included by restricting eigenvalues of photon and atomic population operators to discrete integral values and by using equivalent noise sources. The total output fluctuations increase monotonically with output power; the relative fluctuations decrease monotonically, and at high output levels inversely as the output power squared. The low-frequency fluctuations differ in that the relative fluctuations increase with output below threshold (noise amplifier region) but decrease sharply above threshold (dynamic saturation region). Curves typical of gas, solid, and diode lasers are illustrated. The theory agrees well with preliminary experimental results. (Author)

#### A66-18442

##### PHOTON ECHOES.

I. D. Abella, N. A. Kurnit, and S. R. Hartmann (Columbia University, Radiation Laboratory, New York, N. Y.). *Physical Review, 2nd Series*, vol. 141, Jan. 1966, p. 391-406. 30 refs.

Contracts No. DA-31-124-ARO-D-224; No. DA-28-043-AMC-00099(E).

Experiments are described in which a dilute ruby crystal is found to emit spontaneously a short pulse of light, the photon echo, at a time  $\sim T_2$  after irradiation by two successive ruby-laser pulses separated by  $T_2$ . The phenomenon is explained in terms of a macroscopic oscillating electric dipole moment, which is momentarily reformed at the time the photon echo is observed. The analysis predicts the echo polarization as well as the propagation direction relative to the input pulses. A necessary condition for obtaining echoes in ruby is the application of a moderate magnetic field close to the optic axis of the crystal, and a simple model



based on  $\text{Cr}^{3+}$ -Al interactions is offered to account for this magnetic-field behavior. The relaxation time of the echo is found to exceed 250 nsec at 4.2°K but to be less than 70 nsec at 14°K, and is thought to be due to phonon-induced transitions in the excited  $^2E(E)$  level. Multiple echo formation is also described. (Author)

#### A66-18487

##### METHOD FOR DETERMINING THE PEAK IRRADIANCE OF AN OPTICAL PUMP AND TOTAL PUMP ENERGY THAT IS INCIDENT UPON A LASER CRYSTAL.

Thomas J. Negrelli (Systems Research Laboratories, Inc., Dayton, Ohio).

Review of Scientific Instruments, vol. 36, Dec. 1965, p. 1755-1759. 11 refs.

USAF-supported research.

A method has been developed for determining the peak irradiance of an optical pump and the total pump energy incident upon a number around the boron atom - namely, the solid solution of V in  $\text{Co}_2\text{B}$  and a ternary phase with the  $\text{Cr}_{23}\text{C}_6$  structure. In the Co-rich corner of the ternary system a liquidus projection and an isothermal section at 800°C are worked out. The solubility of V in  $\text{Co}_2\text{B}$  at 800°C is 8 at.%. The substitution of V in  $\text{Co}_2\text{B}$  is accompanied by an increase in the tetragonal lattice parameters  $a$  and  $c$ , but by a decrease in the axial ratio  $c/a$ . The correlation between the average number of outer electrons and the axial ratio of this structure is discussed and illustrated by several examples. At 800°C the congruently melting ternary phase extends from  $\text{Co}_{21}\text{V}_2\text{B}_6$  to  $\text{Co}_{20}\text{V}_3\text{B}_6$ , and its Bo content remains practically stoichiometric; its lattice constant also increases with increasing V content and, for alloys quenched from 800°C, lies between 10.47<sub>6</sub> and 10.49<sub>7</sub> Å.

R.A.F.

#### A66-18488

##### HYDROFLUORINATION UNIT FOR PURIFICATION OF FLUORIDE LASER MATERIALS.

Stanley I. Warshaw and Robert E. Jackson (Raytheon Co., Research Div., Waltham, Mass.).

Review of Scientific Instruments, vol. 36, Dec. 1965, p. 1774-1776. 10 refs.

Description of an apparatus for the fluoridation of hydroxyl- and oxygen-contaminated fluoride compounds. This purification process yields oxide-free fluorides. Optically clear lanthanum trifluoride crystals were grown from material subjected to this treatment. No evidence of Tyndall scattering was observed with the naked eye when a beam of white light was passed through the crystal. To compensate for some moisture absorption on the surface of the ingot, less than 1/2-% by weight of lead fluoride was added to the pretreated batch as an oxygen scavenger.

F.R.L.

#### A66-18609 \*

##### (EXO) ELECTRON EMISSION FROM LASER-RUBY CRYSTALS.

B. Sujak (Wrocław, Uniwersytet, Katedra Fizyki Doświadczalnej, Zakład Wzbudzonej Emisji Elektronów, Wrocław; Wyższa Szkoła Pedagogiczna, Katedra Fizyki Doświadczalnej, Opole, Poland) and A. Niklas (Wyższa Szkoła Pedagogiczna, Katedra Fizyki Doświadczalnej, Zakład Fizyki Powierzchni Ciała Stałego, Opole, Poland). Acta Physica Polonica, vol. 28, Nov. 1965, p. 729-731. 5 refs.

Preliminary results on thermostimulated, induced electron emission from samples cut from laser ruby crystals. The emitted electrons were detected with an open point counter of the vapor quenching type. The samples of  $\text{Al}_2\text{O}_3 + \text{Cr}^{+++}$  (0.05% by weight) and  $\text{Al}_2\text{O}_3 + \text{Cr}^{+++}$  (0.1% by weight) were cut from rods of ruby single crystals. The samples were in all cases irradiated at room temperature with unfiltered X rays for 15 min (60 kv, 3.5 ma anode current and Cu anode) before the electron glow curves were measured. The typical curves of thermostimulated electron emission from the crystals indicate that the higher concentration of  $\text{Cr}^{+++}$  ions quenches the induced electron emission.

D.P.F.

#### A66-18632

##### INTENSIFICATION OF A He-Ne GAS DISCHARGE FOR THE $\lambda = 6328$ -Å LASER WAVELENGTH [VERSTÄRKUNG EINER He-Ne-GASENTLADUNG FÜR DIE LASERWELLENLÄNGE $\lambda = 6328$ ÅE].

G. Herziger, W. Holzapfel, and W. Seelig (Berlin, Technische Universität, 1. Physikalisches Institut, Berlin, West Germany). Zeitschrift für Physik, vol. 189, no. 4, 1966, p. 385-400. 31 refs. In German. Research sponsored by the Volkswagenwerk.

Experimental investigation of the optical gain of He-Ne discharges for the 6328-Å laser wavelength. Measurements are made using two independent techniques and the results are found to be identical. The gain of the He-Ne discharge is measured for a number of discharge tubes with different tube lengths and diameters. The experiments show that maximum gain is a function of these tube dimensions if the total gas pressure and discharge current are optimized. The optimum values for both gas pressure and current increase with smaller tube diameters. The gain over the cross section is expressed by a Bessel function of zero order.

D.P.F.

#### A66-18637

##### STATISTICAL MODEL OF A RANDOM QUASI-SINUSOIDAL FUNCTION OF CONSTANT AMPLITUDE [ETUDE D'UN MODELE STATISTIQUE DE FONCTION ALEATOIRE QUASI SINUSOIDALE A AMPLITUDE CONSTANTE].

Etienne Boileau (Paris, Université, Institut d'Electronique, Orsay, Seine-et-Oise, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 261, no. 25, Dec. 20, 1965, p. 5297-5300. 8 refs. In French.

Study of a statistical model of a random quasi-sinusoidal function of constant amplitude represented by the emission of a laser or of a radio transmitter. After defining the analytic signal, the moment grouping is calculated.

F.R.L.

#### A66-18648

##### COHERENCE AND STIMULATION THRESHOLD OF A STOKES LINE [COHERENCE ET SEUIL DE STIMULATION D'UNE RAIE STOKES].

Geneviève Rivoire (Reims, Université, Faculté des Sciences, Groupe d'Optique et Spectroscopie, Reims, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 261, no. 25, Dec. 20, 1965, p. 5393-5396. 8 refs. In French.

Demonstration that an important divergence exists between the calculated intensity  $W'$  of a stimulated Stokes line as a function of the intensity  $W_0$  of the exciting laser line and the corresponding measured value. The measured intensity  $W'$  is, for values of  $W_0$  located in the vicinity of the threshold of obtention of the stimulated Raman effect, from  $10^6$  to  $10^8$  times higher than the calculated value of  $W'$ . Introducing the concept of coherence in the theory of Placzek (or of Einstein) makes it possible to correct the  $10^6$ -to- $10^8$  factor.

F.R.L.

#### A66-18650

##### LASER EFFECT IN CADMIUM SULFIDE BY ELECTRON BOMBARDMENT [EFFET LASER DANS LE SULFURE DE CADMIUM PAR BOMBARDEMENT ELECTRONIQUE].

Claude Benoit à la Guillaume and Jean-Marie Debever (Paris, Université, Ecole Normale Supérieure, Laboratoire de Physique, Paris, France).

Académie des Sciences (Paris), Comptes Rendus, vol. 261, no. 25, Dec. 20, 1965, p. 5428-5430. 7 refs. In French.

Production of the laser effect at 4 and 20°K in pure cadmium sulfide crystals which were bombarded by a beam of electrons at 20 keV. The directivity of the laser emission and the successive axial modes of the cavity were observed. The emission occurred in the neighborhood of 4910 Å, or 2.525 eV.

F.R.L.

#### A66-18700

##### LASERS - HALF A DECADE OF DEVELOPMENT.

G.G. MacFarlane (Ministry of Aviation, Royal Radar Establishment, Great Malvern, Worcs., England).

Institution of Electrical Engineers, Hunter Memorial Lecture, 8th, London, England, Jan. 6, 1966.

Electronics and Power, vol. 12, Feb. 1966, p. 40-43.

Review of laser development from the time of the first demonstration with a ruby crystal excited by light from a pulsed xenon flash lamp, through semiconductor and ion lasers, to the  $N_2 - CO_2$  laser, which gives a continuous output of 20 watts at  $10.6 \mu$  wavelength, with an efficiency of better than 4%, or more than 40 times that of other gas lasers. Basic laser theory is briefly discussed. The inverted system, whereby the radiation emitted is distributed in frequency in a certain bandwidth in the vicinity of the resonance, is described. Attention is given to pumping methods, optically pumped lasers, gas discharge lasers, gaseous ions, and semiconductors.

F. R. L.

**A66-18918 #**

TWO-FREQUENCY VOLUME RESONATOR WITH INDEPENDENT TUNINGS [DVOUKHCHASTOTNYI OB'EMNYI REZONATOR S NEZAVISIMYMI NASTROIKAMI].

V. M. Sedykh.

*Radiotekhnika (Kiev)*, vol. 8, Sept. - Oct. 1965, p. 601, 602. In Russian.

Description of a two-frequency resonator capable of independent tuning on each frequency within wide frequency bands. In this resonator the tuning elements for each resonance frequency are located in those parts of the resonator where the field of the other resonance frequency cannot penetrate. Structurally, the resonator is shown to consist of a regular-waveguide segment, one end of which merges smoothly into a waveguide with a higher critical frequency, while the other end merges into a bandpass waveguide filter.

A. B. K.

**A66-18930**

MEASUREMENTS OF ELECTROMAGNETIC BACKSCATTERING FROM KNOWN, ROUGH SURFACES.

Jacques Renau and James A. Collinson (Bell Telephone Laboratories, Inc., New York, N. Y.).

(Union Radio-Scientifique Internationale, Meeting, Washington, D. C., Apr. 2, 1965, Paper.)

*Bell System Technical Journal*, vol. 44, Dec. 1965, p. 2203-2226. 13 refs.

We have measured the cross section for backscattering of laser beams from rough aluminum surfaces and a magnesium oxide slab. These surfaces were specially prepared and their statistical properties were measured. The laser wavelengths were  $\lambda = 0.63, 1.15$ , and  $3.39 \mu$ , and both parallel and perpendicular polarizations were used. The angle of incidence was varied from  $0$  to  $89^\circ$ . In these experiments the ratio of the surface rms height  $h$  (from the mean surface) to the wavelength  $\lambda$  is larger than  $1/4$ ; for such surfaces the cross section for backscatter at normal incidence is inversely proportional to the square of the rms surface slope,  $h/\lambda$ , and is independent of wavelength. At large angles of incidence the cross section increases with increasing slope and also with increasing  $h/\lambda$ , approaching an upper limit which appears to be predicted by a Lambert scattering law. The angular dependence of the cross section differs for the two polarizations; at grazing incidence the cross section is larger for the parallel polarization. The published characteristics of the angular dependence of the cross section of microwave backscattering from the sea and the moon are in remarkable agreement with the backscattering cross section obtained from the various randomly rough laboratory prepared surfaces at all angles of incidence. Comparison of the laboratory results with published moon data yields for the moon surface an rms height of  $40 \pm 10$  cm, a mean correlation distance or mean scale size of  $2.8 \pm 0.7$  meters, an rms slope of  $8 \pm 4^\circ$ , and a dielectric constant at microwave frequencies of  $1.9 \pm 0.3$  Gc.

(Author)

**A66-18970**

A Q-SWITCHED NEODYMIUM GLASS LASER.

N. G. Basov, V. S. Zuev, and Iu. V. Senatskii (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, June 1965, p. 1562-1564.)

*Soviet Physics - JETP*, vol. 21, Dec. 1965, p. 1047, 1048. 5 refs. Translation.

[For abstract see issue 24, page 3595, Accession no. A65-35875]

**A66-18972**

HEATING OF MATTER BY FOCUSED LASER RADIATION.

R. V. Ambartsumian, N. G. Basov, V. A. Boiko, V. S. Zuev, O. N. Krokhin, P. G. Kriukov, Iu. V. Senatskii, and Iu. Iu. Stoilov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). (Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 48, June 1965, p. 1583-1587.)

*Soviet Physics - JETP*, vol. 21, Dec. 1965, p. 1061-1064. 12 refs. Translation.

[For abstract see issue 24, page 3595, Accession no. A65-35877]

**A66-19063 #**

HIGHER ORDER CALCULATION OF THE LAMB DIP IN THE OUTPUT OF AN OPTICAL MASER.

Kiyoji Uehara and Koichi Shimoda (Tokyo, University, Dept. of Physics, Tokyo, Japan).

*Japanese Journal of Applied Physics*, vol. 4, Nov. 1965, p. 921-927.

A higher order calculation of the theory of an optical maser is carried out for the purpose of obtaining more accurate theoretical expressions of the Lamb dip. The amplitude of maser oscillation is calculated in the approximations up to the fifth order and the calculated power vs frequency characteristics by the third and the fifth order approximations are compared. The Lamb dip becomes considerably shallower if the fifth order term is included. The fifth order calculation should therefore be employed for a more accurate determination of the linewidth parameters of the active atoms from observed shapes of the Lamb dip. It is shown, however, that the correction due to the fifth order calculation is small when the relative excitation is very close to the threshold. The fifth order calculation in the case when the "Doppler limit" does not apply is also discussed as well as in the case of the "Doppler limit."

(Author)

**A66-19118 #**

NEW TECHNIQUES IN OPTICS. I [TECHNIQUES NOUVELLES EN OPTIQUE. I].

P. Mollet.

(Société Belge d'Astronomie, de Météorologie et de Physique du Globe, Conférence, Brussels, Belgium, May 22, 1965, Paper.) *Ciel et Terre*, vol. 81, Sept. - Oct. 1965, p. 290-321. In French.

Review of some new developments in the field of optics including interference filters, lasers, and optical fibers. The theory of the phenomenon of light interference is considered followed by a description of a practical Fabry-Perot type of interferometer. Various types of interferometric filters are discussed; all of them incorporate two or more metallic partially transparent layers and a dielectric layer or layers separating them. The theory which describes the nature and behavior of coherent light is reviewed; Bohr's quantum theory explains the manner in which optical lasers generate coherent electromagnetic waves in the visible spectrum. Practical laser operation and various types of lasers are discussed.

D. P. F.

**A66-19195**

COHERENT RADIATION FROM GALLIUM-ARSENIDE LUMINESCENT DIODES WITH A TRIANGULAR RESONATOR.

E. A. Poltoratskii, V. M. Stuchebnikov, and A. E. Iunovich (Moskovskii Gosudarstvennyi Universitet, Fizicheskii Fakul'tet, Moscow, USSR).

(Zhurnal Tekhnicheskoi Fiziki, vol. 35, Aug. 1965, p. 1516-1521.) *Soviet Physics - Technical Physics*, vol. 10, Feb. 1966, p. 1173-1176. 15 refs. Translation.

[For abstract see issue 24, page 3567, Accession no. A65-36787]

**A66-19200**

ONSET OF DETONATION.

P. A. Urtiew and A. K. Oppenheim (California, University, Berkeley, Calif.).

*Combustion and Flame*, vol. 9, Dec. 1965, p. 405-407. 6 refs. Grant No. AF AFOSR 129-65.

Experimental proof showing that the onset of retonation is also the onset of detonation. The proof is based on the use of two completely independent techniques. One, reported to be quite unsophisticated, utilizes the unique ability of the self-sustained detonation wave to "write on the walls," the record being obtained on a carbon-soot covered film. The other exploits recent developments in laser technology, permitting the attainment of high repetition rate, extremely high resolution schlieren stroboscopic records of wave phenomena. M. F.

#### A66-19232

##### RAMAN SPECTROSCOPY USING A GAS LASER.

J. P. Russell (Ministry of Aviation, Royal Radar Establishment, Great Malvern, Worcs., England). (Colloque International sur les Spectres de Diffusion des Cristaux, Paris, France, July 6-8, 1965.) *Journal de Physique*, vol. 26, Nov. 1965, p. 620-625; Discussion, p. 625, 626. 10 refs.

Use of a helium-neon gas laser (which is more intense than the mercury arc, has a longer wavelength (6328 Å), and is plane polarized) in Raman spectroscopy. The experimental arrangement utilized commercially available apparatus. The scattered radiation is normally observed at right angles to the direction of the laser beam, but a slight modification allows the observation of backscattered radiation, the angle between the laser beam and the direction of observation being about 45°. The first- and second-order Raman spectra of calcium tungstate, calcium fluoride, and gallium phosphide were measured. Three-phonon Raman scattering was observed for GaP. The experimental results are presented in two numerical tables. F. R. L.

#### A66-19269

##### THE CHANGE IN THE EMISSION SPECTRUM OF A RUBY LASER DURING GENERATION.

A. M. Kubarev and V. I. Piskarev (Gor'kovskii Gosudarstvennyi Universitet, Radiofizicheskii Institut, Gorki, USSR). (*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, May 1965, p. 1233-1236.) *Soviet Physics - JETP*, vol. 21, Nov. 1965, p. 823-825. 5 refs. Translation. [For abstract see issue 24, page 3594, Accession no. A65-35866]

#### A66-19271

##### ON THE THEORY OF GAS LASERS.

A. K. Popov (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Fizicheskii Institut, Krasnoyarsk, USSR). (*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 48, May 1965, p. 1279-1282.) *Soviet Physics - JETP*, vol. 21, Nov. 1965, p. 856-858. 7 refs. Translation. [For abstract see issue 24, page 3594, Accession no. A65-35868]

#### A66-19367

##### DECAY OF LASER-INDUCED EXCITATIONS OF F CENTERS.

Dietmar Fröhlich and Herbert Mahr (Cornell University, Dept. of Engineering Physics, Laboratory of Atomic and Solid State Physics, Ithaca, N. Y.). *Physical Review*, 2nd Series, vol. 141, Jan. 1966, p. 692-695. 17 refs. Navy-ARPA-supported research.

A strong population of excited F-center states is achieved in various alkali halides using a short intense pulse of a Q-switched ruby laser. During the presence of the excited F centers the time dependence of their decay is measured with a fast-recording spectrometer. This is done by monitoring the absorption changes connected with the ground-state or excited-state populations. Using this method for crystals containing low F-center concentrations, the lifetime of the excited state of F-centers in KI, RbI, CsI, RbBr, and CsF is measured from 7 to about 80°K by monitoring absorption

changes in the region of the  $\beta$ , the  $\beta^*$  and the F band, respectively. For KI samples containing high F-center concentrations it is found that the decay curves are nonexponential. (Author)

#### A66-19376 #

##### CaF<sub>2</sub>:Dy<sup>2+</sup> OPTICAL GENERATOR OPERATING IN A REGIME OF REPEATING GIANT PULSES IN THE PRESENCE OF CONTINUOUS PUMPING [OPTICHESKII GENERATOR NA CaF<sub>2</sub>:Dy<sup>2+</sup>, RABOTA-IUSHCHII V REZHIME POVTORAIUSHCHIKHSIA GIGANTSKIKH IMPUL'SOV PRI NEPRERYVNOI PODKACHKE].

V. K. Konukhov, V. V. Kostin, L. A. Kulevskii, T. M. Murina (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR), and A. M. Prokhorov. *Akademiia Nauk SSSR, Doklady*, vol. 165, Dec. 11, 1965, p. 1056-1058. 8 refs. In Russian.

Observation of a laser regime in which repeating giant pulses are generated in CaF<sub>2</sub>:Dy<sup>2+</sup> in the presence of continuous pumping by xenon lamps. In this investigation modulation of the Q factor is achieved with the aid of a rotating prism. An average radiation power of 0.05 watt is obtained with a stationary prism and with a prism rotating at a frequency of 200 cps, so that this frequency is assumed to be close to the optimum frequency. From these measurements of average radiation power in a modulated Q-factor regime the peak radiation power is determined and is found to be equal to  $2 \times 10^3$  watts. A. B. K.

#### A66-19546

##### HIGH POWER CW LASER OPERATION BY CATHODOLUMINESCENCE.

J. W. Ogland, C. W. Baugh, and J. E. Hudson (Westinghouse Electric Corp., Atomic, Defense and Space Group, Aerospace Div., Applied Physics Group, Baltimore, Md.). IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ANNUAL EAST COAST CONFERENCE ON AEROSPACE AND NAVIGATIONAL ELECTRONICS, 12TH, BALTIMORE, MD., OCTOBER 27-29, 1965. TECHNICAL PAPERS. [A66-19487 08-21] Conference sponsored by the Baltimore Section of the Institute of Electrical and Electronics Engineers, and the Aerospace and Navigational Electronics Group. New York, Institute of Electrical and Electronics Engineers, 1965, p. 3.5.3-1 to 3.5.3-5.

Description of a method of laser pumping which spectrally matches the pump radiation to an absorption band of the laser material. This pump radiation is obtained by the high-voltage electron excitation of a suitably chosen phosphor whose emission spectrum matches the principal absorption band of the laser. The high reflectivity of phosphors allows for good optical coupling of the pump light into the laser rod. A CW laser incorporating such a cathodoluminescent laser pump is described. Considerations for the selection of suitable phosphors are discussed. P. K.

#### A66-19620 #

##### GENERATION IN CdS DURING TWO-PHOTON OPTICAL EXCITATION BY RUBY-LASER EMISSION [GENERATSIIA V CdS PRI DVUKHFOTONNOM OPTICHESKOM VOZBUZHDENII IZLUCHENIEM OKG NA RUBINE].

N. G. Basov, A. Z. Grasiuk, I. G. Zubarev, and V. A. Katulin (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). *Fizika Tverdogo Tela*, vol. 7, Dec. 1965, p. 3639, 3640. In Russian.

Results of an experiment in optical excitation of a CdS specimen, using a ruby laser with a modulated Q factor. Measurements are made of the spectral composition, the spectral-line intensity, and the emission directivity of the CdS specimen. It is found that generation occurs in a comparatively large volume of the semiconductor. A. B. K.

#### A66-19638 #

##### THEORY OF THE ZEEMAN EFFECT IN GAS LASERS [K TEORII EFFEKTA ZEEMANA V GAZOVYKH LAZERAKH].

## A66-19667

N. N. Rozanov and A. V. Tulub.  
Akademiia Nauk SSSR, Doklady, vol. 165, Dec. 21, 1965,  
p. 1280-1283. 7 refs. In Russian.

Calculation of nonlinear Zeeman effects for a gas laser. Lamb's (1964) method is generalized to the case of two conditions of polarization  $\mu = 1, 11$  of the electromagnetic field and three electron levels a, b, and c, two of which are related to the higher level ( $J = 1$ ), and one of which is related to the lower level ( $J = 0$ ).

R. A. F.

## A66-19667 #

PHOSPHORESCENCE AND THE ENERGY LEVEL PATTERN OF A RUBY [FOSFORESTSENTSIIA I ZONNAIA SKHEMA RUBINA].

Z. L. Morgenshtern and V. B. Neustruev (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

ZHETF Pis'ma v Redaktsiiu, vol. 2, Dec. 1, 1965, p. 507-510. 5 refs. In Russian.

Report on a phosphorescence observed in ruby crystals excited with several flashes from a 450-joule pulse tube. The phosphorescence has a spectral range within the R region, persists 2 or 3 days and diminishes according to a parabolic law. The study of the nature of the phenomenon suggests a transition band multiphoton or multistage mechanism of electron excitation. The upper wavelength limit of the phosphorescence is given as 6030 Å.

V. Z.

## A66-19669 #

SPECTRAL COMPOSITION OF THE OUTPUT OF A NEODYMIUM GLASS LASER IN A DISPERSION RESONATOR [SPEKTRAL'NYI SOSTAV GENERATSII NEODIMOVOGO STEKLA V DISPERSIONNOM REZONATORE].

V. L. Broude, V. I. Kravchenko, N. F. Prokopiuk, and M. S. Soskin (Akademiia Nauk Ukrainsskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR).

ZHETF Pis'ma v Redaktsiiu, vol. 2, Dec. 1, 1965, p. 519-521. In Russian.

Preliminary results of a study of the threshold parameters and of the spectral composition of radiation of a neodymium-glass laser with a nonuniformly broadened luminescence band at 1.06  $\mu$ . The dependence of the relative threshold pumping energy on the angle of inclination of the resonator mirror is determined. Spectral lines are established at 9090 through 9540  $\text{cm}^{-1}$  which is a range five times greater than the entire range of a conventional plane laser at maximum pumping levels.

V. Z.

## A66-19734 #

MICROMACHINING WITH A PULSED GAS LASER.

H. A. H. Boot, D. M. Clunie, and R. S. A. Thorn (Services Electronics Research Laboratory, Baldock, Herts., England). Electronics Letters, vol. 2, Jan. 1966, p. 1.

Description of a method using a pulsed He-Ne laser for rapid micromachining. The experimental micromachining facility is described and illustrated, and its operation is explained. Although the experiments described use simple samples, the technique is applicable to the micromachining of more complex structures, such as thin-film circuits and resistors.

B. B.

## A66-19902 #

TRACKING OF THE BEACON-EXPLORER SATELLITES WITH LASER BEAMS.

H. H. Plotkin (NASA, Goddard Space Flight Center, Greenbelt, Md.).

COSPAR Information Bulletin no. 29, Dec. 1965, p. 18-21. 6 refs.

Brief review of the results of experiments designed to develop techniques for accurate tracking of orbiting optical reflectors using pulsed ruby laser beams. The cube-corner retroreflectors provided for the Beacon-Explorers B and C (Explorers 22 and 27) are described, as well as time of launch, apogee, perigee, etc., of the satellites. Reflected ruby laser radiation from the Beacon Explorers was used to produce images of the satellites against a star background. It is concluded that the techniques promise to yield precise measurements of satellite position, when they are developed to an operational stage.

M. L.

## A66-19915

SEMICONDUCTOR LASER COMMUNICATIONS THROUGH MULTIPLE-SCATTER PATHS.

E. J. Chatterton (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).

IEEE, Proceedings, vol. 53, Dec. 1965, p. 2114, 2115.

Experimental study employing semiconductor lasers and FM techniques to overcome modulation noise as verified under a full variety of weather conditions over a 1.8 mi path. A liquid nitrogen cooled GaAs noncoherent IR diode was used which was amplitude-modulated by a 28-Mc subcarrier, and the subcarrier was alternately frequency- and amplitude-modulated by a 980-cps audio signal. The radiant power from the 0.5-degree beamwidth transmitter is given as 8 mw. Oscillograms of sample FM and AM optical signals are presented, as recorded under various atmospheric conditions, including severe shimmer, snow, fog, and haze. It is found that measurements of optical pulses transmitted appreciably beyond the limits of visibility in snow and fog indicate a channel bandwidth limited by scatter-multipaths, but quite adequate for many short-range, wide-bandwidth communications applications. A device is described in which laser elements are fabricated with fiber-optic outputs. These techniques are believed to make feasible many applications of high-power, frequency-, and pulse-modulated communications through atmospheric paths.

M. L.

## A66-19922

UNIAXIAL PRESSURE WAVELENGTH CHANGES IN GaAs LASERS IN CW OPERATION.

R. H. Durrett, E. D. Jacobs, J. Winocur, and W. L. Zingery (North American Aviation, Inc., Autonetics Div., Navigation Systems Div., Anaheim, Calif.).

IEEE, Proceedings, vol. 53, Dec. 1965, p. 2121, 2122. 6 refs.

Experimental investigation reporting the change in wavelength of both the spontaneous ( $d\lambda/dp$  spontaneous) and stimulated ( $d\lambda/dp$  stimulated) emission with uniaxial pressure under CW operation of GaAs diode lasers at 4°K. Measurements were made on a GaAs diode doped with Te to a concentration of  $1.5 \times 10^{18}$  atoms/cm<sup>3</sup> using a 0.5-meter Jarrell-Ash grating spectrometer operating in second order with a nitrogen-cooled 7102 photomultiplier tube. The junction was formed by Zn diffusion made parallel to the (100) plane of the diode with a cross-sectional area of  $8.8 \times 10^{-4}$  cm<sup>2</sup>. Typical results of the spectra observed at three pressure levels (61, 78, and 90 bars) are presented. It is found that the patterns are usually different on opposite sides of the emission center, and that increasing pressure decreases the wavelength of the modes about three times faster than the emission center and changes the relative intensities of the components of the patterns.

M. L.

## A66-19930

REFLECTION GRATINGS AS ELEMENTS IN FAR INFRARED MASERS.

Eric Brannen (Western Ontario, University, Dept. of Physics, London, Ontario, Canada).

IEEE, Proceedings, vol. 53, Dec. 1965, p. 2134, 2135. 14 refs.

Research supported by the National Research Council of Canada; Grant No. AF AFOSR 297-65.

Description of the use of reflection echelette gratings as end plates in a Fabry-Pérot cavity with the chief characteristics of convenient low absorption output coupling, and wavelength-dependent alignment of the end plates. It is found that the grating is quite rugged, easily fabricated, and can be coated with protective materials, and that radiation is extracted from the resonator in the zero order of the grating in a convenient manner with little absorption loss. It is noted, however, that the reflectivity of the grating is a function of the polarization of the radiation, being different in general, for the two polarizations parallel and perpendicular to the groove length; thus, polarization discrimination will result. The grating produces a wavelength-sensitive instrument of the Fabry-Pérot, making it quite lossy for wavelengths other than the design region, a property that it is expected should allow the removal of "dominance" by strong transitions, so that weaker transitions, whose upper levels are depleted by a strong transition, may be observed in maser action.

M. L.

**A66-19933****BLOCKING EFFECT IN RUBY MASERS.**

Hikaru Shiota (Nippon Electric Co., Ltd., Central Research Laboratories, Tokyo, Japan).

IEEE, Proceedings, vol. 53, Dec. 1965, p. 2139.

Description of the gain saturation of the ruby maser by a nearby interfering signal, a phenomenon usually called the blocking effect. The saturation behavior of the maser is discussed by treating a magnetic Q, expressed in a form derived from the equations of motion of the density matrix for a three-level maser. The power level of the interfering signal required to drop the maser signal by 3 db, and the paramagnetic absorption of ruby are graphed. Equivalent circuits of a maser cavity for a Lorentzian-type, Gaussian-type, and the actual maser are presented and compared. M. L.

**A66-19934****PULSE-CODE MODULATION MULTIPLEX TRANSMISSION OVER AN INJECTION LASER TRANSMISSION SYSTEM.**

E. J. Schiel, E. C. Bullwinkel, and R. B. Weimer (U.S. Army, Electronics Command, Electronic Components Laboratory, Fort Monmouth, N.J.).

IEEE, Proceedings, vol. 53, Dec. 1965, p. 2140, 2141.

Description of pulsed transmission of information over an electron-injection laser communication system. The CW injection laser used in the study is described, and block diagrams of the transmitter and receiver are presented. A typical example of the received signal over a 13-km path is included. It is found that tone and voice quality are excellent, and it is concluded that this demonstrates the practicality of high-speed, pulse-code modulation multiplex transmission over a laser system. M. L.

**A66-19935****A PROPOSED FIRST-ORDER RELATIVITY TEST USING LASERS.**

R. Fox and J. Shamir (Technion - Israel Institute of Technology, Haifa, Israel).

IEEE, Proceedings, vol. 53, Dec. 1965, p. 2141; Author's comment, C. W. Carnahan (Entech Corp., Menlo Park, Calif.), p. 2141, 2142. 8 refs.

Comment on a previously published proposal for a test of relativity by means of lasers. It is emphasized that the experiment is of a second-order nature, in that the relative phase change of two points is measured. A means is suggested by which the experiment may become first order, namely by rotating the equipment. M. L.

**A66-19937****AN IMPROVED MODE OF KERR CELL OPERATION.**

H. A. Heynau (United Aircraft Corp., Research Laboratories, East Hartford, Conn.).

IEEE, Proceedings, vol. 53, Dec. 1965, p. 2145, 2146.

Experimental investigation of an optically biased pulsed transmission mode (OBPT Mode) of operation of a high-gain, Q-switched laser in order to alleviate the problem posed by the observed fact that not all Kerr cells completely inhibit lasing action. It is considered that the reason for this deficiency arises from spatial non-uniformities in the rejection ratio across the aperture of the Kerr cell polarizer-analyzer combination. The experimental configuration is illustrated, and it is pointed out that the only addition to the system is the quarter-wave plate placed between the polarizer and a reflector. The purpose of the plate is to bias the system (with zero voltage on the Kerr cell), by means of a passive optical element, into the hold-off condition. The modification proposed has been successfully applied to an 18-mm-diameter, 12-in.-long Brewster angle neodymium-doped glass laser. Several advantages are pointed out. M. L.

**A66-19945 #****ON THE GENERATION OF SHARPLY DIRECTED COHERENT RADIATION.**

E. M. Belenov and V. S. Letokhov.

(Optika i Spektroskopiia, vol. 19, Sept. 1965, p. 465-467.)

Optics and Spectroscopy, vol. 19, Sept. 1965, p. 261. Translation.

[For abstract see issue 01, page 83, Accession no. A66-11007]

**A66-19955****BEATS BETWEEN THE MODES OF A RUBY LASER.**

V. V. Korobkin and A. M. Leontovich (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 49, July 1965, p. 10-15.)

Soviet Physics - JETP, vol. 22, Jan. 1966, p. 6-10. 18 refs. Translation.

[For abstract see issue 20, page 2969, Accession no. A65-31701]

**A66-19956****A ROOM-TEMPERATURE CONTINUOUS  $\text{CaWO}_4:\text{Nd}^{3+}$  LASER.**

A. A. Kaminskii, L. S. Kornienko, G. V. Maksimova, V. V. Osiko, A. M. Prokhorov, and G. P. Shipulo (Moskovskii Gosudarstvennyi Universitet, Institut Iadernoi Fiziki; Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 49, July 1965, p. 31-35.)

Soviet Physics - JETP, vol. 22, Jan. 1966, p. 22-25. 11 refs. Translation.

[For abstract see issue 20, page 2969, Accession no. A65-31703]

**A66-19959****INVESTIGATION OF THE SPARK DISCHARGE PRODUCED IN AIR BY FOCUSING LASER RADIATION. II.**

S. L. Mandel'shtam, P. P. Pashinin, A. M. Prokhorov, Iu. P. Raizer, and N. K. Sukhodrev (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, vol. 49, July 1965, p. 127-134.)

Soviet Physics - JETP, vol. 22, Jan. 1966, p. 91-96. 19 refs. Translation.

[For abstract see issue 20, page 2969, Accession no. A65-31705]

**A66-20129 #****MOON DISTANCE MEASUREMENT BY LASER.**

A. Orszag (Ecole Polytechnique, Paris, France).

(Symposium on Planetary Atmospheres and Surfaces, Dorado, Puerto Rico, May 24-27, 1965, Paper.)

Journal of Research, Section D - Radio Science, vol. 69D, Dec. 1965, p. 1681-1689. 7 refs.

Research supported by the Centre National d'Etudes Spatiales, Centre National d'Etudes des Télécommunications, Délégation Générale à la Recherche Scientifique et Technique, and Direction des Recherches et Moyens d'Essais.

Proposed use of a laser light source to determine the earth-moon distance which would have the advantages of making possible direct calculation of the lunar radius directed toward the earth and, if the SNR at reception proved sufficient, the complete determination of the form of the selenoid. In specifying the physical orders of magnitude of the project, it is established that only a Q-switched laser would permit this latter measurement. The performance of the emitting optical system coupled with the laser and that of the optical system and the receiving apparatus are determined. Some of the problems arising in laser utilization are discussed, and a method of exploiting the expected results is proposed. F. R. L.

**A66-20344 #****INDUCED RADIATION AT HIGH PHOTON DENSITIES [INDUTSIROVANNOE IZLUCHENIE PRI BOL'SHIKH PLOTNOSTI AKH FOTONOV].**

B. I. Bondarev.

Radiofizika, vol. 8, no. 6, 1965, p. 1155-1159. 5 refs. In Russian.

Discussion of the applicability of perturbation theory to the study of the multiphoton resonance radiation of lasers. The third term of the expansion in perturbation theory is analyzed as one that describes the interaction of an atomic electron with an external photon, which produces two photons. It is shown that the use of this third term in the calculation of interactions of electrons with photons is incorrect when the photon density is very high. V. Z.

**A66-20364 \***

ABSOLUTE BOLOMETER FOR MEASURING THE OUTPUT POWER OF CW LASERS [ABSOLUTNYI BOLOMETRICHESKII IZMERITEL' VYKHODNOI MOSHCHNOSTI LAZEROV NEPRERYVNOGO IZLUCHE-NIA].

Iu. A. Skliarov, V. A. Sedel'nikov, and L. I. Kats (Saratovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Institut Mekhaniki i Fiziki, Saratov, USSR).

*Priroda i Tekhnika Eksperimenta*, vol. 10, Nov.-Dec. 1965, p. 165-167. 5 refs. In Russian.

Discussion of a device for measuring the output power of a CW laser, which uses a wire bolometer in the form of a plane single-layer spiral as the sensitive element. The device provides recordings in absolute units, and is applicable at output powers ranging from 0.02 to 30 mw. The accuracy of the measurements (after the instrumental error is taken into account) is on the order of  $\pm 5\%$ . The device is capable of measuring radiation in the visible and far-infrared regions of the spectrum.

V. P.

the close analogies between electron-beam generators and microwave amplifiers and laser systems. The measurement problem in laser technology is examined.

V. P.

**A66-20435 #**

EFFECT OF LOAD MISMATCH ON LASER OPERATION [VLIYANIE RASSOGLASOVANIIA NAGRUZKI NA RABOTU OPTICHESKOGO KVANTOVOGO GENERATORA].

V. V. Lebedeva, I. V. Lebedev, and A. I. Odintsov.

*Radiotekhnika (Kiev)*, vol. 8, Nov.-Dec. 1965, p. 632-636. In Russian.

Experimental investigation of the effect of load mismatch on the power output of a neon-helium laser operating at a wavelength of  $0.633 \mu$ . The nonlinear dependence of the equivalent negative conductance is determined as a function of the amplitude of the oscillations in the laser resonator cavity.

V. P.

**A66-20398**

LASER PROBING THE LOWER ATMOSPHERE.

B. R. Clemesha, G. S. Kent, and R. W. H. Wright (West Indies University, Kingston, Jamaica).

*Nature*, vol. 209, Jan. 8, 1966, p. 184, 185. 5 refs. Grant No. AF AFSR 616-64.

Description of density measurements of the lower atmosphere through observation of the light scattered from a laser beam. The experimental facility included an optical radar suitable for detecting the amount of atmospheric scattering, and a Q-spoiled ruby laser, used as the transmitter. The receiving system for the light scattered back by the atmospheric constituents was composed essentially of a 50-cm diam astronomical telescope. A typical night's result of scattering power vs height is plotted, as are variations with height of the ratio of observed scattering to expected molecular scattering.

B. B.

**A66-20517**

1.0621- $\mu$  He-Ne GAS LASER.

I. Itzkan and G. Pincus (Sperry Rand Corp., Sperry Gyroscope Co., Electro-Optics Group, Great Neck, N. Y.).

*Applied Optics*, vol. 5, Feb. 1966, p. 349.

Description of the isolation of the 1.0621 line in He-Ne. An attempt was made to achieve isolation by means of multilayer dielectric-coated mirrors with sharp spectral cutoff characteristics. The results of these efforts are consistent with the observation that transitions with the same upper levels compete for available atoms, but transitions with the same lower levels do not interfere with one another. It is found that even with all competing transitions suppressed, the gain of the 1.0621 line is very low, which explains why it is so difficult to obtain this line with in-cavity components.

B. B.

**A66-20518**

A LASER END REFLECTOR WITH SPECTRAL TUNING CAPABILITY.

Robert M. Zoot (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

*Applied Optics*, vol. 5, Feb. 1966, p. 349, 350.

Outline of the production of a gas laser end reflector that individually selects the spectral line to be lased through use of a Pellin-Broca type prism which is assembled with a reflective coating at an interface. Construction of the prism is described, its operation is explained, and placement of its dielectric coating is indicated in a schematic diagram. It is concluded that this technique should prove useful not only to select each of the eight visible wavelengths of the He-Ne CW gas laser, but the same method may be used to select the various lines of the argon laser as well.

B. B.

**A66-20420**

TIME-DEPENDENT EMISSION BEHAVIOR OF A DIFFRACTION-LIMITED CONTINUOUS RUBY LASER [DAS ZEITLICHE EMISSIONS-VERHALTEN EINES BEUGUNGSBEGRENZTEN KONTINUIERLICHEN RUBINLASERS].

D. Röss (Siemens und Halske AG, Zentrallaboratorium für Nachrichtentechnik, Munich, West Germany).

*Zeitschrift für Naturforschung, Ausgabe A*, vol. 20a, Dec. 1965, p. 1655-1660. 18 refs. In German.

Investigation of the time-dependent emission behavior of a single axial mode at room temperature in the transverse ground mode of a pulsed continuous plane ruby laser 2.5 cm long with a Fabry-Perot interferometer. The total emission is characterized by a quasi-periodic relaxation pulse with periodic modulation of the envelopes. The emission of 11 active axial modes near the threshold of periodic packet emissions of 0.5 to 1 msec duration is limited to approximately equal emission intervals. Even at higher pumping levels the continuous emission component of a mode is small in relation to the peak output in the form of relaxation pulses. A spatially concentrated degradation of the inversion in a laser resonator should be prevented by sweeping the phase surfaces in active materials, which accounts for the multiple axial modes.

D. P. F.

**A66-20434 #**

RELATED PROBLEMS IN THE DEVELOPMENT OF LASER AND MICROWAVE TECHNOLOGY [SMEZHNYE PROBLEMY RAZVITIYA LAZERNOI TEKHNIKI I TEKHNIKI SVERKHVYSOKIKH CHASTOT].

I. V. Lebedev.

*Radiotekhnika (Kiev)*, vol. 8, Nov.-Dec. 1965, p. 625-631. 17 refs. In Russian.

Discussion of the new demands placed on microwave electronics as a result of the development and utilization of lasers. The application of methods used in electronics to laser technology and vice versa is examined. Particular attention is given to the development of microwave photoelectronic devices, to the study of self-consistent gas discharges at optical frequencies, and to the use of

Consideration of the use of superconductors with magnets and masers, including also a discussion of the techniques employed in fabricating superconductor coils. Various sizes and types of magnets are described in which the magnetic coils are immersed in liquid helium. The application of superconductors to masers can reduce a maser's weight by a factor of 50 to 70. The widest potential application for superconducting magnets is for MHD power generation. Intermetallic compounds and alloys are described and the theory of superconductivity is reviewed. Superconducting coil characteristics are considered and winding techniques are discussed.

D. P. F.

**A66-20792 #**

A RESONATOR FOR TUNING A MOLECULAR GENERATOR BY ZEEMAN MODULATION [REZONATOR DLIYA NASTROIKI MOLEKULARNOGO GENERATORA PRI POMOSHCHI ZEEMANOVSKOI MODULIATSII].

V. V. Grigor'iants and Iu. A. Mazurov.

*Radiotekhnika i Elektronika*, vol. 11, Jan. 1966, p. 152-154. In Russian.

Description of a resonator which can be made out of magnetic materials and can still be used for tuning a molecular generator by Zeeman modulation. This is achieved by using a resonator which is cut along its axis in such a way that the cut passes from one end of the resonator to a point several millimeters short of the other end. It is shown that such a resonator can be used as a single-turn coil to create, inside the resonator, a magnetic field perpendicular to the resonator axis. From a study of the dependence of the magnetic field on the modulating current, the length of the resonator, and the angular direction relative to the plane of the longitudinal gap it is found that such a resonator actually can be used for Zeeman modulation of a molecular generator. A. B. K.

#### A66-20519

EFFECT OF ULTRAVIOLET PUMPING ON RUBY LASER OUTPUT. R. L. Greene, J. L. Emmett, and A. L. Schawlow (Stanford University, Dept. of Physics, Stanford, Calif.). *Applied Optics*, vol. 5, Feb. 1966, p. 350, 351. 7 refs. USAF-Navy-supported research.

Investigation of the effect of intense UV pumping radiation upon the energy output of a ruby laser. The experimental facility utilizing a xenon flashlamp is described and illustrated, and its operation is explained. Two experiments to evaluate the effects of UV radiation in laser pumping are described and their results noted. It is concluded from both of these experiments that intense UV pump light is detrimental to ruby laser output. B. B.

#### A66-20568 \*

ON THE REGULAR AND IRREGULAR SPIKING BEHAVIOR OF SOLID-STATE LASERS.

Helmut K. V. Lotsch (Stanford, University, Stanford, Calif.). *International Journal of Electronics, First Series*, vol. 19, Nov. 1965, p. 453-468. 73 refs.

A solid-state laser with plane parallel end faces usually produces an output which exhibits spikes in a random manner, whereas the prevalent quantum relaxation theory predicts regular relaxation oscillations. Recently in a new theoretical approach, the author has shown that in an imperfect crystal the filamentary nature of the laser action is postulated by classical physics. A single filament generates relaxation oscillations as predicted by the familiar theory, and the irregular spiking may then be considered a superposition of outputs from several filaments. This model is supported by many experimental observations and it suggests a reinterpretation of certain experimental data published. The field distributions in a Fabry-Pérot resonator with a sufficiently large Fresnel number can be expressed in terms of parabolic cylinder functions. The mode volume of a low-order eigenmode is considerably smaller than the crystal volume. Accounting for this fact in the quantum relaxation theory yields that the decay time constant of the relaxation oscillations is actually smaller than predicted by the linearized Statz and deMars rate equations. This is in favorable agreement with experiment. (Author)

#### A66-20856 \*

OPTICAL DOUBLE RESONANCE EXPERIMENTS IN RUBY.

Takashi Kushida and Pravin Parikh (Toshiba Central Research Laboratory, Kawasaki, Japan).

*Physical Society of Japan, Journal*, vol. 20, Dec. 1965, p. 2312, 2313.

Observations on the absorption transitions from the lowest excited state of  $\text{Cr}^{3+}$  ion in a ruby pumped by a ruby laser beam. The energy separation between the  $2E(t_2^3)$  state and the ground state  $4A_2(t_2^3)$  is resonant with the frequency of the ruby laser radiation. The absorption was measured at 2610 and 3600 Å. A diagram of the experimental apparatus is given; the specimen and the laser ruby were both cut off at 90° and cylindrical with a diameter of 10 mm and a length of 10 cm. Concentrations of  $\text{Cr}_2\text{O}_3$  were respectively

about 0.1 and 0.05%. Their optical axes were set parallel and the  $R_1$  laser output was directed into the ruby specimen. The Cary Model 14 monochromator used had a spectral resolution of about 40 Å. Typical oscillograms are graphed and interpreted. D. P. F.

#### A66-20893

OBSERVATION OF PARAMETRIC AMPLIFICATION IN THE OPTICAL RANGE.

S. A. Akhmanov, A. I. Kovrigin, A. S. Piskarskas, V. V. Fadeev, and R. V. Khokhlov (Moskovskii Gosudarstvennyi Universitet, Fizicheskii Fakultet, Moscow, USSR).

(*ZHETF Pis'ma v Redaktsiiu*, vol. 2, Oct. 1, 1965, p. 300-304.)

*JETP Letters*, vol. 2, Oct. 1, 1965, p. 191-193. 7 refs. Translation.

[For abstract see issue 05, page 697, Accession no. A66-15352]

#### A66-20895

INFLUENCE OF INTENSE LASER RADIATION ON THE DISPERSIVE PROPERTIES OF "TRANSPARENT" CRYSTALS.

M. S. Brodin, V. N. Batulev, and S. V. Zakrevskii (Akademiia Nauk Ukrainskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR).

(*ZHETF Pis'ma v Redaktsiiu*, vol. 2, Oct. 1, 1965, p. 317-319.)

*JETP Letters*, vol. 2, Oct. 1, 1965, p. 201-203. 6 refs. Translation.

[For abstract see issue 05, page 697, Accession no. A66-15354]

#### A66-20898

MULTIPHOTON IONIZATION OF THE HYDROGEN MOLECULE IN THE STRONG ELECTRIC FIELD OF RUBY LASER EMISSION.

G. S. Voronov, G. A. Delone, N. B. Delone, and O. V. Kudrevatova (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(*ZHETF Pis'ma v Redaktsiiu*, vol. 2, Oct. 15, 1965, p. 377-380.)

*JETP Letters*, vol. 2, Oct. 15, 1965, p. 237-239. Translation.

[For abstract see issue 06, page 891, Accession no. A66-16517]

#### A66-20901

CONCENTRATION AND TEMPERATURE DEPENDENCES OF THE SPIN-LATTICE RELAXATION TIMES IN RUBY AT HELIUM TEMPERATURES - RELAXATION IN ZERO MAGNETIC FIELD.

A. A. Manenkov and Iu. K. Danileiko (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(*ZHETF Pis'ma v Redaktsiiu*, vol. 2, Nov. 1, 1965, p. 414-418.)

*JETP Letters*, vol. 2, Nov. 1, 1965, p. 257-260. 11 refs.

Translation.

[For abstract see issue 07, page 1044, Accession no. A66-18257]

#### A66-21067

EFFECT OF SOLAR RADIATION ON ATMOSPHERIC LASER RETURNS.

W. E. Hoehne and J. L. Karney (U.S. Navy, Pacific Missile Range, Point Mugu, Calif.).

*Applied Physics Letters*, vol. 7, Dec. 15, 1965, p. 313, 314.

Evaluation of a simple laser radar unit for use as an instrument to obtain operational meteorological information. The operation of the experimental facility (which consists essentially of a ruby laser and two 8-in. Cassegrainian telescopes) is described, and the laser returns at a 10° elevation angle are plotted. It is determined that the amplitude of the return from scatterers in the atmosphere is strongly dependent on the angle between the incident laser radiation and the incident solar radiation. B. B.

#### A66-21070

ISOTOPE SHIFT MEASUREMENT FOR 6328 Å He-Ne LASER TRANSITION.

R. H. Cordover, T. S. Jaseja, and A. Javan (Massachusetts Institute of Technology, Dept. of Physics, Cambridge, Mass.).

*Applied Physics Letters*, vol. 7, Dec. 15, 1965, p. 322-324. 7 refs. NASA-USAF-supported research.

Outline of the measurement of the isotope shift between Ne 20 and Ne 22 for the 6328-Å transition using two different optical maser techniques. The experimental configurations, consisting essentially of two optical masers and two interferometers, are described and

their operation is explained. Because the sensitivity of the photo-diodes employed to detect the cross-beat signal when the masers were in single-mode oscillation was not high enough, therefore a heterodyne technique was introduced, where one of the masers was allowed to operate in multimode configuration. B.B.

**A66-21173****QUANTUM THEORY OF PHOTON INTERACTION IN A PLASMA.**

H. Cheng (Harvard University, Dept. of Physics, Cambridge, Mass.; Bell Telephone Laboratories, Inc., Whippany, N.J.) and Y. C. Lee (Bell Telephone Laboratories, Inc., Whippany, N.J.). Physical Review, 2nd Series, vol. 142, Feb. 4, 1966, p. 104-114. 8 refs.

The quantum theory of interaction of electromagnetic waves in a plasma is formulated from two different points of view. The first is to consider scattering of light off light (in form of laser beams) with the plasma acting as a mediator of the interaction; the second is to consider scattering of one of the light beams off a system consisting of the plasma and the other laser beam. Based on the first viewpoint, the light-light scattering cross sections, both elastic and inelastic, are calculated in the lowest order. By summing over the final states of one of the photons, we obtain, based on the above results, the lowest order cross section of scattering of the other photon from the photon-plasma system. In the presence of a second stimulating laser beam, this cross section is enhanced. When both laser beams are very intense, the lowest order perturbation treatment is inadequate. The second viewpoint is then conveniently adopted to include the plasma-laser beam interaction to all orders. The results are discussed and compared with those in previous treatments. Finally, a simple model is considered. In this model, the plasmon is treated as the quantum of a harmonic oscillator which is linearly coupled to a system of phonons. All the previous results are explicitly verified in this model, which is solved exactly. (Author)

**A66-21175****OPTICAL SECOND-HARMONIC GENERATION USING A FOCUSED GAUSSIAN LASER BEAM.**

J. E. Bjorkholm (Stanford University, Microwave Laboratory, Stanford, Calif.). Physical Review, 2nd Series, vol. 142, Feb. 4, 1966, p. 126-136. 14 refs.

Contract No. AF 49(638)-1525.

This paper reports analytical and experimental results on optical second-harmonic generation in the focus of the lowest order transverse mode of a CW gas laser beam. The results of the calculation are explained in physical terms and are confirmed by experiments carried out in crystals of ammonium dihydrogen phosphate (ADP). The dependence of the second-harmonic power generated in a negatively birefringent crystal upon the crystal double-refraction angle and the divergence, or diffraction, of the focused beam is obtained. There are found to be four distinct asymptotic regions, determined by the ratios of the characteristic lengths  $z_R$  and  $z_L$  to the crystal length  $L$ , where the Rayleigh range of the focused beam  $z_R$  characterizes the focus, and is characteristic of the crystal double-refraction angle  $\alpha$  and  $L$  the laser beam focal spot size  $w_0$ . Proceeding from weak focusing to strong focusing (or in the direction of decreasing  $w_0$ ), the second-harmonic power in the four regions varies as  $L^2/w_0^2$ ,  $L/\alpha$ ,  $w_0/\alpha$ , and  $w_0^2$ , respectively. There is an optimum degree of focusing, determined only by the crystal length for which a maximum amount of second-harmonic power is generated. This degree of focusing corresponds to  $z_R = L/\pi$ , and the corresponding power which is generated depends upon both  $L$  and  $\alpha$ . Optimum focusing in a crystal of ADP 1 cm long yields about 400 times more second-harmonic power than the collimated laser beam. The excellent agreement between analysis and experiment allows the accurate measurement of optical nonlinearities using focused beams. The results for the general case of a crystal anywhere along the focused beam are also presented. Interpretation of them shows that the limiting of second-harmonic generation by double refraction is determined by beam divergence not beam radius. (Author)

**A66-21177****THEORY OF DOUBLE RESONANCE IN GASEOUS LASERS.**

W. C. Culshaw (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Research Laboratories, Palo Alto, Calif.). Physical Review, 2nd Series, vol. 142, Feb. 4, 1966, p. 204-216. 14 refs.

Research supported by the Lockheed Independent Research Program.

The simultaneous action of an rf perturbation between the Zeeman sublevels of an atomic transition, which is also producing laser oscillation, is considered. The complete Hamiltonian of the system is made time-independent by appropriate unitary transformations, and the corresponding steady-state solutions of the density matrix are deduced using appropriate rate constants. Results for stationary atoms indicate a dependence of the threshold for oscillation on the rf perturbation, together with rf resonance effects which increase the laser intensity some two or three times for suitable transitions. The increase in intensity is greatest for rf perturbations between the upper Zeeman levels, which also have the smaller resonance width, because of the longer lifetimes involved. Such effects will be small unless there is a reasonable difference in the populations of the Zeeman levels in the absence of the rf perturbation. Appropriate laser transitions, cavity tuning, and polarization characteristics must thus be used to obtain maximum effect, and examples are given. The atomic motion is included in the theory in an approximate way, and similar conclusions are derived as regards the variations of laser intensity. However, no dependence of the threshold on the rf perturbation is then indicated, the former being determined by the relatively large Doppler width. Finally, some consideration is given to cases where more than one laser transition occurs between the Zeeman levels. (Author)

**A66-21248****QUASICONTINUOUS RUBY GIANT PULSE LASER USING A SATURABLE ABSORBER AS A Q SWITCH.**

Dieter Roess and Günter Zeidler (Siemens und Halske AG, Zentral-laboratorium, Munich, West Germany). Applied Physics Letters, vol. 8, Jan. 1, 1966, p. 10-12. 9 refs.

Study of the Q-switching of a room-temperature continuously pumped ruby laser with an external mirror by a saturable absorber at 100 and 300 cps. An increase in peak power by a factor of  $10^3$  and a reduction of pulse halfwidth from 2  $\mu$ sec to 70 nsec were observed. The periodic giant pulse emission was obtained in one stable axial and transverse mode. The experimental facility, consisting essentially of a 90° ruby rod and an external mirror of 200 mm radius is described and illustrated, and its operation is explained. It is concluded that the passive Q-switching technique, besides its ease of application, offers the additional feature of single-mode emission. B.B.

**A66-21250****A SINGLE-FREQUENCY TEM<sub>00</sub>-MODE GAS LASER WITH HIGH OUTPUT POWER.**

M. DiDomenico, Jr. (Bell Telephone Laboratories, Inc., Murray Hill, N.J.). Applied Physics Letters, vol. 8, Jan. 1, 1966, p. 20-22. 5 refs.

Report of a new laser configuration which makes it possible to generate single-frequency radiation in a single spatial mode with high output power. Single-frequency operation is achieved by utilizing a technique where all resonances but one, falling within the gain profile of the active medium, are suppressed. The system consists basically of a Michelson interferometer modified to have gain in each branch of the interferometer and a feedback reflector  $M_C$  for coupling these branches. M.F.

**A66-21251****MODE LOCKING OF A Nd<sup>3+</sup>-DOPED GLASS LASER.**

A. J. DeMaria, C. M. Ferrar, and G. E. Danielson, Jr. (United Aircraft Corp., Research Laboratories, East Hartford, Conn.). Applied Physics Letters, vol. 8, Jan. 1, 1966, p. 22-24. 9 refs. Contract No. DA-28-043-AMC-00259(E).

Report of the results of mode-locking experiments with Nd<sup>3+</sup>-doped glass lasers. It was found that Nd<sup>3+</sup>-doped glass laser still



oscillated in the conventional random pulsating manner under mode-locked conditions. Mode locking was also performed with 25- and 43-cm-long glass rods with less successful results as a consequence of the optical length variation of the rods during the optical pumping flash. Preliminary experiments on mode locking of each of the three laser rods while Q switched by a rotating prism resulted in damage to all three rods by the high light flux. M. F.

#### A66-21308

##### THE EFFECT OF NONUNIFORM POPULATION DISTRIBUTIONS IN MASERS.

F. J. Rosenbaum (Washington University, Dept. of Electrical Engineering, St. Louis, Mo.) and W. Q. Jeffers (Illinois, University, Dept. of Electrical Engineering, Urbana, Ill.).

IEEE Journal of Quantum Electronics, vol. QE-1, Dec. 1965, p. 375-385. 16 refs.

Description of a dielectric cavity maser (DCM), composed of a ruby rod separating two metal end plates. Both the strength of the maser action, as measured by the paramagnetic filling factor, and the saturation behavior of the device have been calculated and measured. When operated as an X-band amplifier, pumped at 35 Gc, gain bandwidth products up to 141 Mc have been observed. Power outputs greater than 0.1 mw have been measured using the DCM as an amplifier or an oscillator. Improvement in the saturation behavior of ~20 db compared to other masers is reported. M. M.

#### A66-21309

##### PUMP POWER DEPENDENCE OF RUBY LASER STARTING AND STOPPING TIME.

A. E. Siegman and J. W. Allen (Stanford University, Dept. of Electrical Engineering and W. H. Hansen Laboratories of Physics, Microwave Laboratory, Stanford, Calif.). (RESEARCH ON SOLID STATE OPTICAL MASERS.)

IEEE Journal of Quantum Electronics, vol. QE-1, Dec. 1965, p. 386-393. 17 refs.

Contracts No. DA-28-043-AMC-00446; No. DA-36-039-SC-90839; No. AF 33(615)-1411.

Consideration of experimental results from a number of small ruby lasers which show a linear relationship between the pump power and the inverse of the time delay between pump flash and the onset of laser oscillation. These experimental results are quantitatively predicted by a simple rate-equation analysis, yielding a single theoretical curve with no adjustable parameters and in good agreement with the experiments. Additional evidence is also presented verifying the onset at higher pump powers of additional bouncing-ball or light-pipe modes of oscillation in ruby rods with polished sidewall. It is pointed out that these additional modes account, in particular, for the abrupt cessation of laser output after an anomalously short duration of laser action, as is typically observed in such rods. M. M.

#### A66-21310

##### NOISE PROPERTIES OF PULSED RUBY LASER AMPLIFIERS.

I. J. D'Haenens (Notre Dame, University, Physics Dept., Notre Dame, Ind.) and C. R. Giuliano (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

IEEE Journal of Quantum Electronics, vol. QE-1, Dec. 1965, p. 393-397. 7 refs.

Contract No. AF 33(657)-8769.

The spontaneous emission noise properties of a pair of pulsed ruby laser amplifiers have been studied. Absorption and scattering loss measurements coupled with gain measurements as a function of pump time gave a measure of the inversion attained in the amplifiers. The high inversions reached enabled the authors to overcome the inherent noisiness of a three-level system by having  $N_2$  considerably larger than  $(m_2/m_1) N_1$ . Total spontaneous emission power was measured at gain saturation for each amplifier. Comparison of the observed with the theoretically expected spontaneous noise power gave good agreement. (Author)

#### A66-21311

##### SPIKING BEHAVIOR OF A MULTIMODE RUBY LASER.

C. A. Sacchi and O. Svelto (Milano, Politecnico, Istituto di Fisica, Milano, Italy).

IEEE Journal of Quantum Electronics, vol. QE-1, Dec. 1965, p. 398-400. 7 refs.

Research supported by the Consiglio Nazionale delle Ricerche.

Discussion of experimental studies of regular spiking obtained with a ruby rod in a spherical resonator. It was found that not only a transverse but also a longitudinal mode selector leads to irregular spikes. The observed near-field patterns shown are interpreted as a superposition of many transverse modes. Following the interpretation given, it is stated that, in a multimode laser, spikes will be regular if scattering centers produce a superposition of oscillating modes such that a uniform spot in the near field and a uniform frequency spectrum result. It is pointed out that any selector of either longitudinal or transverse modes generally destroys this uniform superposition and the result is irregular spikes. M. M.

#### A66-21333 #

##### APPLICATION OF OPTICAL QUANTUM GENERATORS (LASERS) IN PHOTOGRAPHY [PRIMENENIE OPTICHESKIKH KVANTOVYKH GENERATOROV (LAZEROV) V FOTOGRAFI].

V. N. Sintsov.

Zhurnal Nauchnoi i Prikladnoi Fotografii i Kinematografii, vol. 11, Jan.-Feb. 1966, p. 65-68. 19 refs. In Russian.

Brief discussion of the photographic uses of lasers since Courtney-Pratt's work in 1962. Both interferometric and holographic techniques are considered. R. A. F.

#### A66-21343

##### ON THE EIGENVALUES OF A CLASS OF INTEGRAL EQUATIONS ARISING IN LASER THEORY.

Harry Hochstadt (Brooklyn, Polytechnic Institute, Dept. of Mathematics, Brooklyn, N. Y.).

SIAM Review, vol. 8, Jan 1966, p. 62-65. 7 refs.

NSF Grant No. GP-165.

Proof of an existence theorem for nonzero eigenvalues for some integral equations encountered in studying laser resonant cavities. This is a direct result of a theorem of Fredholm (1903).

R. A. F.

#### A66-21357 #

##### SINGLE-FILAMENTARY JUNCTION LASER.

Akira Kawaji, Hiroo Yonezu, and Yoshihiro Yasuoka (Nippon Electric Co., Ltd., Semiconductor Div., Kawasaki, Japan).

Japanese Journal of Applied Physics, vol. 4, Dec. 1965, p. 1024, 1025.

Description of a single-filament junction laser emitting coherent light of the simpler modes. It is shown that the laser has two portions, each with a selective diffused region. It is noted that when both electrodes were connected with the same current source, the half-width of each lasing spike was less than 0.7 Å. The shift of stimulated emission to high-energy modes with increasing current density that was observed is shown, together with an anomalous far-field pattern which was observed at single-mode operation. M. M.

#### A66-21417

##### SUPERCONDUCTING MAGNET FOR VARIABLE BANDWIDTH TRAVELING WAVE MASERS.

L. M. Troxel (Bell Telephone Laboratories, Inc., Allentown, Pa.).

IEEE Transactions on Magnetics, vol. MAG-1, Dec. 1965, p. 378-381. 8 refs.

In order to amplify microwave signals with optimum gain, the ruby crystal of a 4-Gc traveling wave maser requires a 3300-gauss magnetic field uniform to 0.1%. By properly varying the magnetic field along the length of the ruby crystal, the bandwidth of the maser amplifier can be increased at the expense of gain. A compact superconducting magnet is described, which provides the required magnetic field. The field is obtained from a short solenoid, which is

## A66-21453

made to appear infinitely long through the use of a low reluctance enclosure. A portion of the resulting uniform field can be modified by a superconducting trimmer coil imbedded in the low reluctance enclosure. This coil produces an adjustable stepped magnetic field which allows for varying maser bandwidth. Alternatively, it can be used to operate two independent masers in a single magnetic structure. A high degree of reliability is attained. Problems of flux jumping have been avoided by a design in which the diamagnetic (magnetic insulating) properties of superconducting materials play a minor role. (Author)

### A66-21453 #

#### PULSED-LASER THRUSTOR RESEARCH.

Rita E. Biss, F. A. Giori (Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.), and A. S. Gilmour, Jr. (Cornell Aeronautical Laboratory, Inc., Wave Electronics Section, Buffalo, N.Y.).

American Institute of Aeronautics and Astronautics, Electric Propulsion Conference, 5th, San Diego, Calif., Mar. 7-9, 1966, Paper 66-230. 8 p.

Members, \$0.75; nonmembers, \$1.50.

Contract No. NAS 3-5919.

The electron and ion emission from various metallic surfaces illuminated by a focused, pulsed ruby laser was investigated for possible electric thruster application. The emitted particles have been measured to be over 99% ionized. Most of the charged particles and, in particular, over 60% of the emitted positive ions leave the target surface contained within a conical plume configuration with a semiangle of  $30^\circ$ . The application of an external magnetic field increases the ions contained within this semiangle to over 85%. The laser-excited ion-emission velocity is approximately 4 km per second (yielding a specific impulse of 400 sec) and varies slightly for the different materials investigated. These values can be increased considerably by the use of accelerating potentials although such a technique was not used during this program. Thrusts of up to 3.5 mlb were measured with a pulse length of 700  $\mu$ sec. The available thrust was determined by the ruby laser configuration and power supply capability rather than by a limitation in the laser-generated emission process. (Author)

### A66-21550

#### NONLINEAR LASER NOISE AND COHERENCE.

J. A. Fleck, Jr. (California, University, Lawrence Radiation Laboratory, Livermore, Calif.).

Journal of Applied Physics, vol. 37, Jan. 1966, p. 188-193. 23 refs.

The effect of spontaneous emission noise on the coherence properties of a laser operating above threshold is considered on the basis of a noise-driven van der Pol oscillator model. The oscillator constants are derived from the theory of Lamb. The noise function is represented as a sequence of randomly phased, damped, sine pulses with a Doppler spread of frequencies. The noise function is normalized on the basis of equilibrium considerations at positive temperatures. The nonlinear linewidth, intensity fluctuations, and intensity correlation function are derived. (Author)

### A66-21564

#### OPTICAL FREQUENCY PLASMA RESONANCE IN GASES.

R. W. Minck and W. G. Rado (Ford Motor Co., Scientific Laboratory, Dearborn, Mich.).

Journal of Applied Physics, vol. 37, Jan. 1966, p. 355-358. 7 refs.

An intense optical beam is reflected backward from a laser-induced spark in argon and nitrogen gas at high pressures. The reflected beam is about 10% as intense, diverges with a comparable angle, and has the same frequency (to within about 0.01  $\text{cm}^{-1}$ ) as the incident beam. By simultaneously focusing a weak second harmonic beam onto the discharge, the reflectivity at the higher frequency was measured. One percent of the incident harmonic beam was reflected in a nearly collimated beam, and with no apparent frequency shift (less than 0.05  $\text{cm}^{-1}$ ). The proposed model is that stationary region having very high electron density ( $n_e \approx 2 \times 10^{21}$  electrons/ $\text{cm}^3$ ) is created in the focal volume and exhibits plasma resonance at the laser frequency. The resonance would appear quite damped due to the high collision rate.

Experiments have been performed which support the hypothesis and discriminate against several other possible explanations such as reflection from the mismatch of index of refraction at the shockfront, stimulated Brillouin scattering, and stimulated plasma-wave scattering. (Author)

### A66-21570

#### EFFECT OF THE DIRECT-INDIRECT TRANSITION ON THE HALL EFFECT IN $\text{Ga}(\text{As}_{1-x}\text{P}_x)$ .

C. M. Wolfe, N. Holonyak, Jr., C. J. Nuese, G. E. Stillman, M. D. Sirkis (Illinois, University, Dept. of Electrical Engineering and Dept. of Physics, Materials Research Laboratory, Urbana, Ill.), and D. Hill (Monsanto Co., St. Louis, Mo.).

Journal of Applied Physics, vol. 37, Jan. 1966, p. 434. 7 refs.

USAF-ARPA-supported research.

Hall measurements on homogeneous bulk  $\text{Ga}(\text{As}_{1-x}\text{P}_x)$  over a wide range of x values which show the effect of the direct-indirect transition and its occurrence near  $x = 0.45$ . The results of Hall effect measurements at 300°K on a group of n-type samples of different GaP concentrations are graphed. The generally good agreement between experimental points and the calculated curve is independent evidence that in  $\text{Ga}(\text{As}_{1-x}\text{P}_x)$  the direct-indirect transition occurs quite near  $x = 0.45$ . In addition, the results presented emphasize the need for care in interpreting Hall and resistivity measurements on  $\text{Ga}(\text{As}_{1-x}\text{P}_x)$ . M.F.

### A66-21577

#### LASER ACTION IN SULFUR USING HYDROGEN SULFIDE.

Ramon U. Martinelli and H. J. Gerritsen (Radio Corporation of America, RCA Laboratories, Princeton, N.J.).

Journal of Applied Physics, vol. 37, Jan. 1966, p. 444, 445. 5 refs.

Discussion of the observation of cw laser action on the  $4p^3P_2 - 4s^3S^0_1$  transition of sulfur-I, using hydrogen sulfide-noble gas mixtures. It is noted that no laser action was found at 1.065  $\mu$ . It is pointed out that it may be that the losses in the system used were too large to sustain oscillations on this line. Since this line is unclassified as a sulfur-I line, it may well be that the reported 1.065  $\mu$  line is due to some molecular species in the  $\text{SF}_6$ -noble gas discharge used by Patel et al. M.M.

### A66-21579

#### EFFECTIVE MASS IN $\text{InAs}$ AND $\text{InSb}$ FROM THE LANDAU SHIFT OF PEAK EMISSION IN LASER DIODES.

A. N. Chakravarti (Calcutta, University, University College of Technology, Institute of Radio Physics and Electronics, Calcutta, India).

Journal of Applied Physics, vol. 37, Jan. 1966, p. 446.

Discussion of a communication suggesting that studies of the Landau shift of peak emission in laser diodes as obtained by the application of a magnetic field also provide a direct method of measurement of the scalar effective mass. This is shown by determining the effective mass in  $\text{InAs}$  and  $\text{InSb}$  from such studies recently reported for these semiconductors. M.M.

### A66-21583

#### LASER-STIMULATED NUCLEATION IN A BUBBLE CHAMBER.

R. C. Stamberg and D. E. Gillespie (Michigan, University, Dept. of Nuclear Engineering, Ann Arbor, Mich.).

Journal of Applied Physics, vol. 37, Jan. 1966, p. 459-461. NSF-NASA-supported research.

Discussion of the fact that it has been found that bubble chambers can be made sensitive to nucleation stimulated by a pulsed ruby laser with output at 6943 Å. A 6-in.-diam bubble chamber containing  $\text{CBrF}_3$  (Freon) at 30.7°C was used with a 6% free volume before compression. The chamber was more sensitive to laser-stimulated nucleation than radioactive-stimulated nucleation from a powerful gamma ray source. Shadow photographs showed that the threshold for nucleation from the laser beam occurred below 0.2 mJoule/ $\text{cm}^2$  while

increases in the energy of the laser beam to 25 mJoules/cm<sup>2</sup> caused a greater number of bubbles to form, using a constant superheat condition. The bubbles reached visible size 50 msec after the laser beam entered the chamber. It is pointed out that the formation of bubbles was apparently caused in the superheated bubble chamber by the absorption of a large number of photons from the laser beam onto a trace of minute particles (mostly dust) floating in the liquid Freon.

M. M.

**A66-21656**

**A PROPOSED FIRST-ORDER RELATIVITY TEST USING LASERS.**  
J. Shamir and R. Fox (Technion - Israel Institute of Technology, Dept. of Physics, Haifa, Israel).

IEEE, Proceedings, vol. 53, Aug. 1965, p. 1155, 1156; Author's Reply, Chalon W. Carnahan (Entech Corp., West Menlo Park, Calif.), p. 1156.

Demonstration that Carnahan's proposed first-order "ether drift" experiment using two lasers is actually of a second-order nature. The optical section of Carnahan's experimental facility including two lasers having different (angular) frequencies is illustrated schematically. The conclusions are based on the proposition that if - on switching of the ether drift - the wavelength of the beam traveling with the drift increases (thus decreasing its phase length), then the beam going against the drift would have its wavelength decreased and its phase length increased. Since these phase shifts appear without change in the phase of the difference frequency component, the difference in phase of this component at the two ends of the beams should be the sum of the absolute values of the shifts at each end. This proposition is examined, and the analysis seems to indicate that the individual phase shifts cancel, except for terms of second order in  $v/c$ . Carnahan, however, points out that a closer analysis shows that one of the incremental phase shifts due to the ether drift appears with the wrong sign in the final equations of Shamir and Fox - which accounts for the cancellation of the first-order effect.

B. B.

**A66-21690 #**

**EXPERIMENTAL STUDY OF BREAKDOWN PHENOMENA IN ARGON GAS BY A LASER BEAM AT LOW PRESSURE.**

Che Jen Chen (California Institute of Technology, Jet Propulsion Laboratory, Propulsion Research and Advanced Concepts Section, Pasadena, Calif.).

American Institute of Aeronautics and Astronautics, Plasma-dynamics Conference, Monterey, Calif., Mar. 2-4, 1966, Paper 66-176, 12 p. 17 refs.

Members, \$0.75; nonmembers, \$1.50.

A Q-switched giant pulse laser is focused in an argon gas of pressure less than one atmosphere. The gas breakdown at the focal point is observed by both an electrostatic probe and a phototube. The number density of the charged particles produced as a function of time at different pressures is obtained by measuring the conductivity of the plasma drop produced at the focal point of the laser beam. The energy of the electrons in the plasma drop is obtained from the measurement of the time rate of growth of the size of the plasma drop. The rate of ionization and electron energy of the plasma drop are also calculated by assuming that some preexisting electrons gain energy from photons through the inverse bremsstrahlung process, and lose their energy to atoms mainly through inelastic ionizing collisions. Because of the agreement between theoretical and experimental data, it is thought that associated inverse bremsstrahlung is the main mechanism responsible for the breakdown of the gas by the laser beam. The plasma drop can be used as a tracer to measure the velocity of flow (both unionized and ionized gases) by using the drum camera and probe techniques. Velocity profiles measured using the tracer technique are presented.

(Author)

**A66-21712**

**DIFFUSION OF LIGHT BY PLASMA ELECTRONS IN THE LABORATORY [DIFFUSION DE LA LUMIERE PAR LES ELECTRONS D'UN PLASMA EN LABORATOIRE].**

J. P. Watteau (Commissariat à l'Energie Atomique, Paris, France). (Société Française des Electroniciens et des Radioélectriciens, Conférence sur la Diffusion des Ondes dans les Plasmas, Feb. 4, 1965, Lecture.)

L'Onde Electrique, vol. 46, Jan. 1966, p. 62-74. 24 refs. In French.

Observation of laser light which has been diffused by electrons of a laboratory-produced plasma, despite the existence of a very small effective diffusion area. Following a simplified theoretical exposition, the diffusion of an electromagnetic wave by a plasma is discussed, taking into account electron-ion interactions, with emphasis on the principal conclusions necessary for experimental interpretation. The experimental devices used are described, as well as the results which have been obtained in various French and foreign laboratories. This diagnostic method provides useful data, although it is difficult to operate.

F. R. L.

**A66-21834**

**PHOSPHORESCENCE AND BAND STRUCTURE OF RUBY.**

Z. L. Morgenshtern and V. B. Neustruev (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(ZHETF Pis'ma v Redaktsiiu, vol. 2, Dec. 1, 1965, p. 507-510.)

JETP Letters, vol. 2, Dec. 1, 1965, p. 316-318. 6 refs. Translation.

[For abstract see issue 08, page 1234, Accession no. A66-19667]

**A66-21836**

**SPECTRAL COMPOSITION OF GENERATION OF NEODYMIUM GLASS IN A DISPERSION RESONATOR.**

V. L. Broude, V. I. Kravchenko, N. F. Prokopiuk, and M. S. Soskin (Akademiia Nauk Ukrainskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR).

(ZHETF Pis'ma v Redaktsiiu, vol. 2, Dec. 1, 1965, p. 519-521.)

JETP Letters, vol. 2, Dec. 1, 1965, p. 324-326. Translation.

[For abstract see issue 08, page 1234, Accession no. A66-19669]

**A66-21857**

**DESIGN OF A 4 GC/S NITROGEN-COOLED NON-DEGENERATE PARAMETRIC AMPLIFIER.**

D. Chakrabarty, G. F. D. Millward, and D. Geden (General Post Office, Research Station, London, England).

Radio and Electronic Engineer, vol. 31, Jan. 1966, p. 27-32. 9 refs.

The design of a 4 Gc nitrogen-cooled nondegenerate parametric amplifier suitable for installation at the focus of a dish antenna in a communication-satellite-system earth-station is described. Two single-diode amplifiers, each of 15 db gain and 70 Mc bandwidth to the -3 db points, are cascaded to provide a minimum gain of 30 db and a -3 db staggered tuned bandwidth of 60 Mc with 1 db ripple in the passband. The noise temperature of the amplifier including a cooled circulator when cooled to 77°K is 35 ± 5°K (with contributions from the waveguide connections and external circuitry increasing the overall noise temperature to 46 ± 5°K).

(Author)

**A66-21879 #**

**THE EFFECTS OF SILICON AND SELENIUM DOPING ON GALLIUM ARSENIDE LASER CHARACTERISTICS.**

C. D. Dobson (International Telephone and Telegraph Corp., Standard Telecommunication Laboratories, Ltd., Harlow, Essex, England).

British Journal of Applied Physics, vol. 17, Feb. 1966, p. 187-190. 9 refs.

Research sponsored by the Ministry of Defence.

Over 1000 GaAs lasers, prepared from selenium- and silicon-doped ingots, were compared for efficiency and threshold at different donor concentrations. The reported difference in solubility processes for electrically inactive silicon and selenium impurities was found to make no significant difference to the characteristics of lasers with either impurity doping. Optimum doping levels for efficiency and threshold were found to occur in the low 10<sup>18</sup> carriers/cm<sup>3</sup> range. A tendency for the high current efficiencies to occur at lower carrier concentrations than the threshold minimum was apparent. At 82°K, thresholds of 1600 amp-cm<sup>-2</sup> and efficiencies of around 45% were found to be common at optimum doping levels.

(Author)

**A66-21963 #**

NONLINEAR AMPLIFICATION OF A LIGHT PULSE [Nelineinoe usilenie impul'sa sveta].

N. G. Basov, R. V. Ambartsumian, V. S. Zuev, P. G. Kriukov, and V. S. Letokhov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 50, Jan. 1966, p. 23-34. 19 refs. In Russian.

Theoretical and experimental study of the passage of a powerful pulse of light through a laser operating at saturation regime. It is shown (1) that the velocity of the pulse maximum is substantially higher than the velocity of light when a pulse is amplified nonlinearly without substantially reducing its duration, and (2) that a steepening of the leading edge of the input pulse is required to reduce the duration of a nonlinearly amplified light pulse. In the experiments, steepening was achieved by cutting off the leading edge with an extra valve, which reduced to 4.7 nanosec the duration of a nonlinearly amplified pulse. V. Z.

**A66-21966 #**

MULTIPHOTON IONIZATION OF A XENON ATOM BY RADIATION FROM A RUBY LASER [Mnogofotonnaia ionizatsiia atoma ksenona izlucheniem rubinovogo lazera].

G. S. Voronov and N. B. Delone (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 50, Jan. 1966, p. 78-84. 8 refs. In Russian.

Description of experiments on multiphoton ionization of a xenon atom in a powerful electric field created by a ruby laser ( $h\nu = 1.79$  ev). It is shown that in a field of about  $10^7$  v/cm the ionization effect within  $\sim 10^{-8}$  sec is proportional to approximately the sixth power of the photon flux intensity. The experimental results coincide in order of magnitude with the theoretical results for the dependence of the ionization probability of a six-photon process on the intensity of the electric field. V. Z.

**A66-21970 #**

OPTICAL RESONATOR FOR A LASER WITH A LIQUID ACTIVE COMPONENT [Opticheskii rezonator dlia kvantovogo generatora s zhidkim aktivnym veshchestvom].

V. P. Bykov.

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 50, Jan. 1966, p. 140-143. In Russian.

Theoretical considerations of the construction of lasers with solutions of complex compounds of rare-earth elements used as active components. A laser of this type is proposed and oscillations it may produce are investigated. The effects on laser performance of the inhomogeneity of the liquid active component that may result from intense pumping are discussed. Design suggestions are made for lasers of this type. V. Z.

**A66-21990 #**

PLASMA DIAGNOSTICS BY SCATTERING OF LIGHT AT ELECTRONS [Diagnosticska plazmy po rasseianiiu sveta na elektronakh].

G. M. Malyshev (Akademiia Nauk SSSR, Fiziko-Tekhnicheskii Institut, Leningrad, USSR).

*Zhurnal Tekhnicheskoi Fiziki*, vol. 35, Dec. 1965, p. 2129-2142. 35 refs. In Russian.

Survey of Soviet and foreign papers dealing with plasma diagnostics with the aid of the scattering of laser beams at plasma electrons. An analysis of results obtained over a wide range of electron concentrations and temperatures indicates good agreement between theory and experiment. It is found that the method makes it possible to obtain some results (distribution curves and various local plasma parameters) not attainable by other methods. The range of applicability of the method is assessed. V. P.

**A66-22026 #**

METHOD OF KINETIC EQUATIONS IN THE THEORY OF GENERATION OF A SECOND OPTICAL HARMONIC [Metod kineticheskikh uravnenii v teorii generatsii vtoroi opticheskoi gar-moniki].

I. A. Marushko and V. S. Mashkevich.

*Optika i Spektroskopiia*, vol. 20, Jan. 1966, p. 117-127. 13 refs. In Russian.

Study of certain problems of the theory of generation of a second harmonic by laser beams of finite spectral width, using an analysis based on the method of quantum transitions. The angular dependence of the intensity of the second harmonic in the transmitted and reflected beams is investigated for the case of a plane-parallel plate. Using the method of kinetic equations, the shape of the lines of the fundamental frequency and the harmonic is investigated for a given shape of the pumping line at the fundamental frequency. The line at the fundamental frequency is found to broaden in the general case during generation of a harmonic. The harmonic line in certain cases (pumping line of Gaussian shape) is observed to have a tendency to relative contraction. The case of a pumping line with a Lorentz shape is also considered. A. B. K.

**A66-22027 #**

MEASUREMENT OF THE METASTABLE-LEVEL POPULATION OF THE WORKING SUBSTANCE OF A LASER [Izmerenie naseleennosti metastabil'nogo urovnia rabochego veshchestva lazera].

A. P. Aleksandrov, V. N. Genkin, and M. I. Kheifets.

*Optika i Spektroskopiia*, vol. 20, Jan. 1966, p. 133-137. 6 refs. In Russian.

Consideration of the question of the use of the luminescence-saturation phenomenon for determining the degree of excitation of a metastable state. Simple relationships making it possible to calculate the population of the working level of a laser substance are obtained. A description is given of the experimental method, and the results of measurements of luminescence saturation of ruby specimens are cited. It is shown that the relative number of excited molecules averaged over the volume of the specimen can be obtained with the aid of this method. A. B. K.

**A66-22028 #**

THE QUESTION OF THE ANGULAR DISTRIBUTION OF THE EMISSION ENERGY OF A LASER [K voprosu o raspredelenii energii izlucheniia lazera po uglam].

V. M. Podgaetskii, O. G. Korneeva, and A. N. Chernets.

*Optika i Spektroskopiia*, vol. 20, Jan. 1966, p. 138-142. 8 refs. In Russian.

Certain results of measurements of the radiation pattern of the emission of a ruby laser for various resonators and various laser operating regimes. The values of the width of the radiation pattern at the level of half the maximum intensity - the "angular half-width" are cited, and it is shown that the laser operating regime has no appreciable effect on this width. A. B. K.

**A66-22032 #**

MONOCHROMATIZATION OF THE RADIATION FROM A RUBY LASER WITH A COMPLEX RESONATOR [Monokhromatizatsiia izlucheniia lazera na rubine so slozhnym rezonatorom].

S. M. Mamedzade.

*Optika i Spektroskopiia*, vol. 20, Jan. 1966, p. 178-180. In Russian.

Description of a multiplex light filter (resonator) with components nearly equal in effective thickness, designed for the excitation of a ruby laser. The end faces of the crystal and of the glass rod are coated with dielectric mirrors to quench the radiation bands of both components. As a consequence, the laser can produce radiation on a certain single wavelength. V. Z.

**A66-22046**

HIGH-SENSITIVITY FAST-RESPONSE LASER DETECTION SYSTEMS.

M. Ross (McDonnell Aircraft Corp., Space Div., Advanced Electronics Dept., St. Louis, Mo.), R. B. Hankin (Douglas Aircraft Co., Inc., Electrooptics Dept., Santa Monica, Calif.), E. P. Dallafior, and R. H. Swendsen (Hallcrafters Co., Chicago, Ill.). IEEE Transactions on Aerospace and Electronic Systems, vol. AES-2, Jan. 1966, p. 62-73. 8 refs.

Contract No. NAS 5-3777.

Electrooptical systems exist which can make use of the available bandwidth and directivity at optical frequencies without utilizing the coherence aspects of lasers. The development of a sensitive, very high-speed (microwave response) photoelectric detector, which can function as a high-gain microwave amplifier and mixer, is described. Systems are described for radar, communications, and reconnaissance purposes. Basic noise considerations are shown. CW and FM-CW optical range and range rate tracking systems are described in which the required detection bandwidth is not a direct function of the range resolution, allowing highly accurate range and range rate determination at low signal levels. Communication systems utilizing non-coherent carriers, microwave subcarriers, and the dynamic crossed field electron multiplier as the detector-amplifier-mixer are described.

(Author)

#### A66-22063

HIGH SPEED PULSE TECHNOLOGY. VOLUME 2 - OPTICAL PULSES - LASERS - MEASURING TECHNIQUES.

Frank B. A. Fröding (Impulsphysik GmbH, Hamburg, West Germany) (Translation of Impulstechnik, Leipzig, Akademische Verlagsgesellschaft Geest und Portig, 1960.) New York, Academic Press, Inc., 1965. 477 p. \$21.50.

This book deals with the theoretical and engineering problems which arise in the capacitor discharge technique. This volume covers such topics as the generation of high-power radiation pulses in the nano-, micro- and millisecond range, discharge sparks and lamps, high-speed cinematography, pulse laser engineering, and the meteorological and military applications of optical pulses in signal transmission and ranging systems. The subjects covered by the author's impulse methods range from deep-sea sound sources to cloud height measurement, as well as the conventional (and the unconventional) electronic flash method of producing and controlling light flashes. Chapter headings include light flash production from a capacitive energy storage, signal transmission and ranging systems by capacitor discharges and lasers, and impulse measuring techniques. Such topics as the application of high-voltage high-frequency sparks in the field of aerodynamics, applications of light impulse signal transmission, measuring and counting of X-ray flashes, and the measuring of sound impulses and shock waves are considered in detail. A bibliography with more than 1000 entries is included.

M. F.

#### A66-22146 #

GALLIUM ARSENIDE LASER EXCITED BY FAST ELECTRONS [OPTICHESKII KVANTOVYI GENERATOR NA ARSENIDE GALLIIA S VOZBUZHDENIEM BYSTRYMI ELEKTRONAMI]. N. G. Basov, O. V. Bogdankevich, and B. M. Lavrushin (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). Fizika Tverdogo Tela, vol. 8, Jan. 1966, p. 21-23. 7 refs. In Russian.

Discussion of a laser with fast-electron excitation, using a GaAs crystal with a carrier concentration of  $10^{15}$  to  $10^{16}$  cm<sup>-3</sup> and a mobility of  $6 \times 10^3$  cm<sup>2</sup> v<sup>-1</sup> sec<sup>-1</sup> at 300°K. The spectra of spontaneous and induced radiation are determined for various current densities of the electron beam, as are the divergence angle of the beam, and laser output power. Some peculiar features of the laser generation mode are examined.

V. P.

#### A66-22174 #

FORCED EMISSION FROM ELECTRON-EXCITED CADMIUM SELENIDE [VYNUZHDENNOE IZLUCHENIE SELENIDA KADMILA PRI ELEKTRONNOM VOZBUZHDENII]. E. L. Nolle, V. S. Vavilov, G. P. Golubev, and V. S. Mashtakov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR). Fizika Tverdogo Tela, vol. 8, Jan. 1966, p. 286, 287. In Russian.

Brief discussion of light emission at 80°K by CdSe single crystals, induced by 150-kev, 10-cps, 0.25-μsec electron beam m pulses. Some emission characteristics are given.

V. Z.

#### A66-22212 #

LASER PLASMA PRODUCTION - A NEW AREA OF PLASMA-DYNAMICS RESEARCH.

R. G. Meyerand, Jr. (United Aircraft Corp., Research Laboratories, East Hartford, Conn.).

American Institute of Aeronautics and Astronautics, Plasmadynamics Conference, Monterey, Calif., Mar. 2-4, 1966, Paper 66-174. 12 p. 20 refs.

Members, \$0.75; nonmembers, \$1.50.

The interaction of extremely high intensity optical frequency electromagnetic radiation with gases and solids is a research area accessible to experimental investigation only with the recent development of high powered lasers. Such studies are important to aerospace activities since they provide a new source of extremely high-density, high-temperature uncontaminated plasma for a variety of studies. Plasma density as high as  $10^{20}$  electrons/cm<sup>3</sup> at gas pressures of 1000-2000 psi can readily be produced by this technique. In addition, solid particles suspended in high vacuum can be irradiated with a laser to produce a fully ionized plasma without surrounding gas. The basic theory of gas breakdown produced by optical radiation is discussed, and the absorption of laser energy in the resultant plasma is described. Theories of the dependence of gas breakdown and energy absorption on gas pressure, gas species and optical field strength are discussed.

(Author)

#### A66-22290

STIMULATED TRAVELING-WAVE RADIATION IN LASERS.

B. L. Zhelev, A. P. Kazantsev, and V. S. Smirnov (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Institut Fiziki Poluprovodnikov, Novosibirsk, USSR).

(Fizika Tverdogo Tela, vol. 7, Sept. 1965, p. 2816-2820.)

Soviet Physics - Solid State, vol. 7, Mar. 1966, p. 2276-2279.

8 refs. Translation.

[For abstract see issue 01, page 82, Accession no. A66-10778]

#### A66-22345

GENERATION OF THE R<sub>2</sub>-LINE OF RUBY IN A CAVITY WITH DISPERSION.

V. L. Broude, O. N. Pogorelyi, and M. S. Soskin (Akademiia Nauk Ukrainskoi SSR, Institut Fiziki, Kiev, Ukrainian SSR). (Akademiia Nauk SSSR, Doklady, vol. 163, Aug. 21, 1965, p. 1342, 1343. Soviet Physics - Doklady, vol. 10, Feb. 1966, p. 756, 757. Translation.

[For abstract see issue 06, page 889, Accession no. A66-16346]

#### A66-22466

THEORY OF INTENSITY AND PHASE FLUCTUATIONS OF A HOMOGENEOUSLY BROADENED LASER.

H. Haken (Stuttgart, Technische Hochschule, Institut für theoretische und angewandte Physik, Stuttgart, West Germany).

(U.S. Navy, Conference of the Physics of Quantum Electronics, San Juan, Puerto Rico, June 28-30, 1965, Paper.)

Zeitschrift für Physik, vol. 190, no. 3, 1966, p. 327-356. 25 refs.

Quantum mechanical nonlinear analysis of the fluctuations of the atomic variables in a set of atoms with three levels which support laser action between the upper or the lower two levels. The atomic line is assumed to be homogeneously broadened; such broadening can be caused by decay into nonlasing modes, the pumping process, and lattice vibrations. A set of suitable collective atomic "modes" are introduced which lead to a simplification of the equations of motion for the Heisenberg operators of the light field and the atomic operators. The simplified equations are applied to a study of single-mode operation above the laser threshold. The light amplitude is decomposed into a phase factor and a real amplitude. A formula is given for the linewidth which is caused by phase fluctuations.

D. P. F.

**A66-22490 #****THEORY OF RAMAN LASERS.**

Tie-Cheng Li and Yu-Ping Ho (Academia Sinica, Peking, Communist China).

*Acta Physica Sinica*, vol. 21, Dec. 1965, p. 1933-1950. 18 refs. In Chinese.

Derivation of equations for the coupling, the first Stokes line, the first anti-Stokes line, and the coherent field for a Raman laser. These expressions are obtained from the Hamiltonian, with the relaxation and dissipation terms introduced phenomenologically. The properties of these equations are analyzed by approximation. The threshold for a Raman laser is obtained, and its temporal behavior is discussed. It is shown that no additional threshold condition is required for the anti-Stokes components. The effect of phonon relaxation and the behavior of the Raman laser with long-lifetime phonons are also discussed.

R. A. F.

**A66-22539****OPTICAL SIMULATION OF MICROWAVE ANTENNAS.**

Arthur L. Ingalls.

*IEEE Transactions on Antennas and Propagation*, vol. AP-14, Jan. 1966, p. 2-6. 17 refs.

It has recently been suggested that microwave antennas may be simulated at optical frequencies using the neon-helium continuous gas laser. The present paper discusses various aspects of this problem and presents a simulation example using as a model the 96-element Australian array used to scan the surface of the sun at 80 Mc. An optical system can be used for simulation in which an objective lens obtains the Fourier transform of the antenna aperture field which may be photographed. An additional lens produces an image of the antenna aperture field in the same air space as the far field pattern, thus permitting photographs of near field as well as far field patterns. Antenna masters are made as optical transparencies using photographic plates or film. Phasing may be obtained by using a variable thickness optical material evaporated on glass. Various combinations of array distribution, antenna weighting, and phasing are possible to simulate. Atmospheric perturbations are introduced on the antenna pattern by the use of two-dimensional phase delay patterns. Photographs are presented of the antenna aperture field, the far field pattern and several intermediate near field patterns.

(Author)

**A66-22670****ADVANTAGES AND PROBLEMS OF COHERENCE AS APPLIED TO PHOTOGRAPHIC SITUATIONS.**

Brian J. Thompson (Technical Operations Research, Burlington, Mass.).

(Society of Photo-Optical Instrumentation Engineers, Technical Symposium, 10th, San Francisco, Calif., Aug. 19, 1965, Paper.) *SPIE Journal*, vol. 4, Oct.-Nov. 1965, p. 7-11. 13 refs.

Review of the coherence parameters important in both conventional and unconventional photographic situations. The coherence interval as a measure of the spatial coherence and the coherence length as a measure of the temporal coherence are reviewed. Contact printing and projection printing with laser light are considered including undesirable interference-fringe effects. Photography in reflected coherent light is discussed, and it is shown that the most undesirable feature of this technique is due to speckle patterns.

D. P. F.

**A66-22739 #****PARASITIC "INTERNAL" TYPES OF OSCILLATION IN OPEN RESONATORS WITH A DIELECTRIC ROD [O PARAZITNYKH "VNUTRENNIKH" TIPAKH KOLEBANII V OTKRYTYKH REZONATORAKH S DIELEKTRICHESKIM STERZHNEM].**

A. L. Mikaelian and Iu. G. Turkov.

*Radiotekhnika i Elektronika*, vol. 11, Feb. 1966, p. 347, 348. In Russian.

Analytical investigation of an experimental finding of the existence of "internal" or "circulating" oscillations in a laser crystal, caused by total reflection from the generatrix of a cylindrical sample. Such oscillations are seen to circulate within the sample (they

do not penetrate beyond the end face) and result in an energy loss from the pumping source. It is shown that the losses decrease with increasing dielectric constant and radius of the sample.

V. P.

**A66-22765 #****ANALYSIS OF THE PERFORMANCE OF SOLID-STATE MULTI-CAVITY MASERS.**

Kuo-Chien Fan and Pei-Liang Shieh.

*Acta Electronica Sinica*, June 1965, p. 150-168. 18 refs. In Chinese.

Systematic analysis, by means of the equivalent-network method, of the performance, including the gain-bandwidth product and the gain instability, of multicavity masers of reflection and transmission type. The influence of the reactive component of the paramagnetic resonance on the gain-bandwidth product is taken into account. The theoretical limit of the gain-bandwidth product of a reflection-type coupled cavity with the final cavity filled with paramagnetic material is discussed. The results are said to provide a basis for selection of a practical maser scheme. It is concluded that a compact double-cavity maser with an input cavity and a silver-plated ruby cavity is an improved configuration for many practical purposes.

A. B. K.

**A66-22867****REGENERATIVE RUBY LASER AMPLIFIERS.**

H. Jacobs, J. Castro, F. A. Brand, C. LoCascio, G. Novick (U.S. Army, Electronics Command, Fort Monmouth, N.J.), and S. Weitz.

*Optical Society of America, Journal*, vol. 56, Feb. 1966, p. 149-156. 14 refs.

Experimental test, using ruby at liquid-nitrogen temperature, of a theory wherein an ideal laser amplifier is treated as a three-medium transmission system and it is predicted that, for a given length, the gain should rise with negative attenuation (population inversion), reach a maximum, decrease rapidly at first, and then gradually approach zero asymptotically. The transmitted power gain was studied by controlling the relative times of firing of two rods, one acting as oscillator, the other as amplifier. When both the oscillator and amplifier rubies were uncoated, they could be made to oscillate for about 100 usec giving a well-defined pulse of quasi-CW operation. The gain of the amplifier increased when the input signal from the oscillator approached the time at which the amplifier went into oscillation. With still further delay of signal relative to the amplifier oscillation period, attenuation in transmission was observed.

M. M.

**A66-22868****MEASUREMENT OF ABSOLUTE WAVELENGTH STABILITY OF LASERS.**

K. D. Mielenz, R. B. Stephens, K. E. Gilliland, and K. F. Nefflen (National Bureau of Standards, Washington, D.C.).

*Optical Society of America, Journal*, vol. 56, Feb. 1966, p. 156-162. 10 refs.

A technique was devised to measure the absolute wavelength stability of a gas laser by direct interferometric comparison with an Hg 198 standard lamp. The apparatus used is described, and its limits of precision are discussed. The wavelength fluctuations of a free-running, unstabilized helium-neon laser were measured and found to be several parts in  $10^7$ . They are attributed to thermal and mechanical instabilities of the laser cavity. Manual control of the laser was seen to yield a wavelength constancy of a few parts in  $10^8$ , comparable to the limits of accuracy of interferometric standard sources.

(Author)

**A66-22874****WAVELENGTH MEASUREMENTS OF HELIUM-NEON LASER EMISSION.**

W. R. C. Rowley and D. C. Wilson (Ministry of Technology, National Physical Laboratory, Standards Div., Teddington, Middx., England).

*Optical Society of America, Journal*, vol. 56, Feb. 1966, p. 259.

Description of wavelength measurements of helium-neon laser emission by means of a double-channel recording interferometer used for accurate wavelength measurements against the krypton-86 primary standard. Two samples of a servocontrolled laser manufactured in the U.S. were made available for these measurements together with a prototype model of British manufacture. Under careful adjustment the two lasers of the same manufacture were found to give closely the same stabilized wavelength, within one part in  $10^8$ , while the other laser gave a significantly different value, possibly owing to different gas pressures and discharge parameters. It is pointed out that both these values are within one part in  $10^7$  of the value for a laser containing natural helium and neon, when stabilized to its peak intensity. M.M.

#### A66-22876

BIBLIOGRAPHY OF THE OPEN LITERATURE ON LASERS. V. Edward V. Ashburn (Lockheed Aircraft Corp., Lockheed-California Co., Burbank, Calif.). Optical Society of America, Journal, vol. 56, Feb. 1966, p. 263-267. Addition of 186 entries to the listing (Parts I-IV) of the bibliographies of the open literature on lasers published in the May 1963, Jan. 1964, June 1965, and Aug. 1965, issues of the Journal of the Optical Society of America. M.M.

#### A66-22893

EXPERIMENTAL CONFIRMATION OF STANDING WAVES IN LASER RESONATORS.

A. M. Ledger (Canadian Westinghouse Co., Ltd., Electronics Div., Aerospace Engineering Dept., Hamilton, Ontario, Canada). Applied Optics, vol. 5, Mar. 1966, p. 476, 477.

Research supported by the Defence Research Board of Canada.

Verification of standing-wave patterns inside a laser resonator, using thin metallic films placed between the external mirrors of a pulsed  $\text{Nd}^{3+}$  laser. The line spacings for gold films placed at various angles to the end mirrors of the laser system were measured and found to compare well with the theoretically calculated spacings. Further tests with films placed at a fixed angle in various randomly chosen positions between the end mirrors and the center of the cavity suggested the presence of an axial-mode selection mechanism in the metallic film-glass substrate combination. A.B.K.

#### A66-22938

OPTICAL DIFFRACTION VELOCIMETER.

G. Stavias (General Precision, Inc., General Precision Aerospace Group, GPL Div., Pleasantville, N.Y.). Instruments and Control Systems, vol. 39, Feb. 1966, p. 99-102. 5 refs.

Use of monochromatic (laser) light, backscattered from a diffuse surface, in novel instrumentation to measure relative velocity between the laser light source and the surface. High accuracy and reliability are implicit. The behavior of backscattered monochromatic light is studied and velocimeter instrumentation is discussed. The optical diffraction velocimeter consists of a laser monochromatic source and a receiver using a photomultiplier preceded (optically) by a ruled optical grating and followed (electrically) by a frequency tracker. Some results of current studies are discussed. M.F.

#### A66-22964

MEASURING THE SHAPE OF THE MOON.

Robert L. Wildey (U.S. Geological Survey, Astrogeology Branch, Flagstaff, Ariz.).

Sky and Telescope, vol. 31, Mar. 1966, p. 147-150.

Discussion of various methods of determining the shape of the moon by measuring the distance from points on the lunar surface to the moon's center of mass. A number of important sources of uncertainty in lunar photogrammetry are pointed out. The possibility of using laser beams to transmit information concerning distances between points on the moon is considered. In spite of a number of formidable difficulties which must be solved, it is thought that the use of optical laser radar is feasible for this purpose. A.B.K.

#### A66-22967

FUNDAMENTAL THEOREM IN QUANTUM OPTICS.

I. R. Senitzky (U.S. Army, Electronics Command, Electronics Laboratories, Institute for Exploratory Research, Fort Monmouth, N.J.).

Physical Review Letters, vol. 15, Aug. 9, 1965, p. 233-235. 15 refs.

Proof of a fundamental theorem in quantum optics. It is shown that all sources on which the effect of a detector and dissipation mechanism is negligible may be treated as classical sources in a given interaction. This proof is based on the connection between the quantum-mechanical properties of a system and the measurability of these properties. The proposed theorem and its associated formalism are distinguished by a clear separation of classical and quantum-mechanical effects of the field and the indication of the physical origin of each. A.B.K.

#### A66-22980 #

THE HELIUM-NEON LASER.

L. Allen and D. G. C. Jones (Sussex, University, Physics Laboratory, Brighton, England).

Advances in Physics, vol. 14, Oct. 1965, p. 479-519. 126 refs.

The physical principles underlying the design and operation of the helium-neon laser are discussed. The various ways in which the system may be used to produce laser radiation are reviewed, as are properties of the radiation, such as its frequency structure, monochromaticity and power density. Attention is also given to the effects of external magnetic fields on the system and methods of stabilization of the output frequency. Finally, the various applications of the device are discussed. (Author)

#### A66-23029

CW X-BAND GaAs MICROWAVE GENERATORS.

W. D. Straub, J. A. Ayer, and H. Roth (NASA, Electronics Research Center, Cambridge, Mass.).

Solid-State Electronics, vol. 9, Mar. 1966, p. 281, 282.

Description of a microwave generator capable of producing coherent CW microwave oscillations at frequencies up to 12 Gc. The oscillations are produced in bulk gallium arsenide samples by means of the Gunn effect. The device is fabricated from single-crystal n-GaAs with a resistivity of  $\sim 2.5$  ohm-cm and a mobility of  $\sim 4500$   $\text{cm}^2/\text{v-sec}$ . Typical dc current-voltage characteristics of the device are plotted. V.P.

#### A66-23080

LASER SCATTERING FROM A BOUND SYSTEM.

J. H. Eberly and W. M. Frank (U.S. Naval Ordnance Laboratory, Silver Spring, Md.).

(Conference on Quantum Electrodynamics of High-Intensity Photon Beams, Durham, N.C., Aug. 1964, Paper.)

Nuovo Cimento, vol. 41B, Feb. 11, 1966, p. 113-122. 5 refs.

Study, in a specific model, of the problem of laser scattering by bound charged particles. The model consists of a nonrelativistic idealized "molecule," which is composed of two oppositely charged parts bound together in a harmonic oscillator potential. The center of mass of the molecule moves freely. The Hamiltonian which describes the coupled system of molecule and laser field is separated into two parts, each of which depends explicitly on the coupling. It is shown that the "larger" of these may be exactly diagonalized by a succession of unitary transformations. The exact eigenstates are then used to compute scattering matrix elements. The cross section for scattering a single photon out of the laser beam is calculated. It is found to depend in a nontrivial way on the structure of the molecule, but it exhibits no nonlinearities such as are found in the free-electron problem. The result is discussed in relation to the free-electron results, and contact is made with the corresponding classical calculation. M.F.

#### A66-23090

THE ATTENUATION OF  $3.392 \mu$  He-Ne LASER RADIATION BY METHANE IN THE ATMOSPHERE.

## A66-23093

T. S. Chu and D. C. Hogg (Bell Telephone Laboratories, Inc., New York, N.Y.).  
Bell System Technical Journal, vol. 45, Feb. 1966, p. 301-306. 5 refs.

Description of the comparative measurements of the propagation of IR waves at 3.392 and 3.508  $\mu$  in clear weather over a 2.6-km path of atmosphere at Holmdel, N.J. The measuring system used antennas and detectors common to the two wavelengths. The excess attenuation at 3.392  $\mu$ , after considering various corrections, is interpreted as absorption by methane in the atmosphere, and is found to be 5.5 db/km. The characteristics of this attenuation are relevant not only to evaluation of the potential use of the 3.392- $\mu$  line for communications, but also to possible application in measurement of the methane content of the atmosphere. B.B.

## A66-23093

LASER CAVITIES WITH INCREASED AXIAL MODE SEPARATION.  
 A. D. White.

Bell System Technical Journal, vol. 45, Feb. 1966, p. 339-343.

Description of two mode-suppression techniques which permit single axial mode operation of gas lasers with mirror separations much larger than  $c/2\Delta\nu_a$ . Mode suppression is achieved by splitting the beam and using a three-mirror cavity. One mode suppression technique uses a calcite rhomb (or a Wollaston or Rochon prism) beam splitter; the other, which is simpler but more restricted in application, makes use of the symmetry of the TEM<sub>01</sub> mode. The split mirror approach is demonstrated experimentally, using mirrors of 1-m radius spaced about 176 and 183 cm apart. It is concluded that because of the increased diffraction angle, the TEM<sub>01</sub> mode is not the best choice for beam propagation; furthermore there appears to be no way of applying the split mirror approach to the TEM<sub>01</sub> mode. B.B.

## A66-23103

IRREGULAR DISTURBANCES IN LENS WAVEGUIDES [REGELLOSE STÖRUNGEN IN LICHTLEITUNGEN].

Detlef Glöge (Braunschweig, Technische Hochschule, Institut für Hochfrequenztechnik, Braunschweig, West Germany).

Archiv der elektrischen Übertragung, vol. 20, Feb. 1966, p. 82-90. 14 refs. In German.

Calculation of the effect of such irregularities in the arrangement of lenses in a lens waveguide as are due to irregular bends or lens displacements. The following two cases are examined: (1) where the lenses are sufficiently large to eliminate diffraction and (2) where the aperture of the lenses is taken into account. It is shown that, in the first case, even very slight bends (curvature radius of 90 km) produce inadmissible deviations of the natural wavelengths from the waveguide axis. In the second case - even where many modes are transmitted with small losses - the disturbances generate higher-order modes which are subject to rapid attenuation. A lens displacement of 0.16 mm in a waveguide with 10-mm-diam gas lenses spaced 5 m apart is shown to produce a 4-db/km loss. V.P.

## A66-23204

TWO-BEAM INTERFEROMETRY BY SUCCESSIVE RECORDING OF INTENSITIES IN A SINGLE HOLOGRAM.

George W. Stroke and Antoine E. Labeyrie (Michigan, University, Ann Arbor, Mich.).

Applied Physics Letters, vol. 8, Jan. 15, 1966, p. 42-44. 7 refs. Navy-supported research.

Theoretical and experimental study showing that two-beam interferometry can be obtained by wavefront reconstruction from a hologram which was recorded by having a coherent background successively interfere in the same latent image, first with the wave "transmitted" through the object and next with the wave incident on the object, or vice versa. The technique used is based on a method termed "holographic intensity interferometry," first described by Gabor and Stroke et al., who first showed that successive addition of intensities in a hologram could be made equivalent to a simultaneous addition of complex amplitudes in an interferometer. The application of this method of holographic intensity interferometry to two-beam interferometry is described, and it is pointed out that the method also allows a further clarification of a particular form of

linearity in holography, according to which successive holographic superposition of complex amplitudes in wavefronts can be made equivalent to a simultaneous superposition in "classical" interferometry. The holographic recording and reconstruction arrangements discussed as a model are illustrated. It is noted that two-beam interferograms are produced which are not affected by aberrations of the interferometer elements. M.L.

## A66-23207

Gd<sub>2</sub>(MoO<sub>4</sub>)<sub>3</sub> - A FERROELECTRIC LASER HOST.

Hans J. Borchardt and Paul E. Bierstedt (Du Pont de Nemours and Co., Inc., Central Research Dept., Wilmington, Del.).

Applied Physics Letters, vol. 8, Jan. 15, 1966, p. 50-52. 7 refs.

Experimental study of a ferroelectric laser host in which pulsed laser operation of (Gd<sub>0.97</sub>Nd<sub>0.03</sub>)<sub>2</sub>(MoO<sub>4</sub>)<sub>3</sub> at -138°C and 25°C is reported; the material is ferroelectric below 159°C. This is believed to be the only known case of a ferroelectric laser. While it is considered possible, in principle, to modulate the laser light with an electric field in a material such as this, no modulation has been demonstrated. The preparation of the host material and the experimental conditions are described. It is noted that when crystals of Gd<sub>2</sub>(MoO<sub>4</sub>)<sub>3</sub> (doped or undoped) are viewed along the c axis, two sets of parallel lines are seen, the sets being perpendicular to each other. The lines are illustrated in several photographs. A number of notable features of these lines are pointed out: they cannot be seen when the crystal is viewed from any direction normal to the c axis; they bear a definite relationship to the crystal structure in that they lie in the a-b plane and appear to form an angle of 45° with the a-b axes; when the crystal is heated to 159°C, the lines abruptly disappear, and when the crystal is cooled below this temperature, the lines rapidly reappear. These observations are reminiscent of what has been found with Rochelle salt. The dielectric constant and the dissipation factor of thin slabs cut from a boule of Gd<sub>2</sub>(MoO<sub>4</sub>)<sub>3</sub> were measured as a function of temperature both with the electric field perpendicular and parallel to the c axis. It is found that with the electric field perpendicular to the c axis, only the dissipation factor goes through a peak at the Curie temperature of 159°C; with the applied field parallel to the c axis, both the dielectric constant and the dissipation factor have peak values at the Curie point. M.L.

## A66-23289

PULSE CIRCUITS FOR SUPPLYING SEMICONDUCTOR OPTICAL GENERATORS.

B. D. Kopylovskii and V. S. Ivanov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Pribury i Tekhnika Eksperimenta, vol. 10, July-Aug. 1965, p. 145-148.)

Instruments and Experimental Techniques, Feb. 1966, p. 887-889. Translation.

[For abstract see issue 01, page 83, Accession no. A66-11042]

## A66-23292

STUDY OF THE OPTICAL PROPERTIES OF CRYSTALS WITH THE AID OF A GASEOUS OPTICAL QUANTUM GENERATOR.

V. P. Chebotaev and V. N. Lisitsin (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Institut Radiofiziki i Elektroniki, Novosibirsk, USSR).

(Pribury i Tekhnika Eksperimenta, vol. 10, July-Aug. 1965, p. 178, 179.)

Instruments and Experimental Techniques, Feb. 1966, p. 924, 925. Translation.

[For abstract see issue 01, page 83, Accession no. A66-11045]

## A66-23293

THE PRODUCTION OF SEMICONDUCTOR LASERS BY CLEAVING.

P. G. Eliseev and A. E. Iunovich (Moskovskii Gosudarstvennyi Universitet, Fizicheskii Fakultet, Moscow, USSR).

(Pribury i Tekhnika Eksperimenta, vol. 10, July-Aug. 1965, p. 180-182.)

Instruments and Experimental Techniques, Feb. 1966, p. 926-928. Translation.



**A66-23296****A DISMOUNTABLE FLASH LAMP FOR A LASER.**

A. K. Sokolov and O. P. Fomin (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii, Institut Atomnoi Energii, Moscow, USSR).

(Priory i Tekhnika Eksperimenta, vol. 10, July-Aug. 1965, p. 239-241.)

Instruments and Experimental Techniques, Feb. 1966, p. 994, 995. Translation.

Description of a dismountable flash lamp for a laser. A cross-sectional scale drawing of the cylindrical lamp and its wiring diagram are given, and oscillograms of the flash lamp and of generation of the ruby laser are illustrated. The results of tests of the lamp when the length of its working part is 130 mm are given. The maximum electrical energy of the flash is found to be 7.5 kjoules for a flash duration of  $\sim 100 \mu\text{sec}$ . B. B.

**A66-23309****INVESTIGATION OF THE HIGH-FREQUENCY DISCHARGE IN A NEON-HELIUM LASER.**

N. I. Krindach, I. A. Silin-Bekchurin, L. N. Tunitskii, and E. M. Cherkasov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Zhurnal Tekhnicheskoi Fiziki, vol. 35, Sept. 1965, p. 1678-1684.)

Soviet Physics - Technical Physics, vol. 10, Mar. 1966, p. 1297-1301. 10 refs. Translation.

[For abstract see issue 01, page 82, Accession no. A66-10704]

**A66-23352****THE LASER INTERFEROMETER AS A DIAGNOSTIC TOOL IN SHOCK-TUBE EXPERIMENTS.**

Robert W. Deuel, Leonard P. Kirchner, and Edward Thornton (Illinois Institute of Technology, Research Institute, Chicago, Ill.). Applied Physics Letters, vol. 8, Feb. 1, 1966, p. 59, 60. 8 refs. Contract No. DA-49-146-XZ-391.

Examination of the usefulness of the laser interferometer in diagnosing shock waves. As described by Thornton, the laser is introduced into one arm of a Mach-Zehnder interferometer and the other arm is passed through the shock tube parallel to the end plate. This permitted observation of the reflected shock of a Mach 9 wave in argon at an initial pressure of 1 mm Hg. The properties determined from the laser interferogram may be compared to values calculated for the same shock conditions by Reaser, Lin, and Kantrowitz. Their results are an equilibrium temperature at 10,900°K and 7% ionization. M. F.

**A66-23353****APPLICATION OF  $\text{CCl}_4$  AND  $\text{CCl}_2:\text{CCl}_2$  ULTRASONIC MODULATORS TO INFRARED OPTICAL HETERODYNE EXPERIMENTS.**

F. E. Goodwin and M. E. Pedinoff (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

Applied Physics Letters, vol. 8, Feb. 1, 1966, p. 60, 61. 8 refs.

Contract No. AF 33(615)-1593.

Use of ultrasonic modulation to produce a frequency-shifted IR laser beam which was used as a local oscillator signal to perform heterodyne detection experiments on solid-state diodes. The experimental results show that the sensitivity of the indium arsenide detector is improved in excess of four orders of magnitude by the heterodyne system. A comparison of IR transmittance data and ultrasonic attenuation data led to the selection of carbon tetrachloride and ethylene tetrachloride for measurement at 3.5  $\mu$ . M. F.

**A66-23354****Q SWITCHING OF MOLECULAR LASER TRANSITIONS.**

M. A. Kovacs, G. W. Flynn, and A. Javan (Massachusetts Institute of Technology, Dept. of Physics, Cambridge, Mass.).

Applied Physics Letters, vol. 8, Feb. 1, 1966, p. 62, 63.

USAF-NASA-supported research.

Observation that molecular laser transitions involving levels with long lifetimes are good candidates for application of Q-switching techniques. These techniques make it possible to obtain repetitive pulses of short duration and high peak intensities and also provide a

powerful means for the study of various molecular relaxation processes. A  $\text{CO}_2$ - $\text{N}_2$  laser interferometer system was employed. The maximum Q-switch pulse repetition rate obtainable with rotating mirrors was 500 cps. The optimum Q-switch performance was obtainable at the highest mirror rotation speeds. At low speeds multipulsing would occur. In general, the optimum Q-switched operation was extremely sensitive to the condition of the NaCl windows. Furthermore, the optimum pressures for Q-switched and CW operation were also different. M. F.

**A66-23355****VIBRATIONAL AND ROTATIONAL STUDIES USING Q SWITCHING OF MOLECULAR GAS LASERS.**

G. W. Flynn, M. A. Kovacs, C. K. Rhodes, and A. Javan (Massachusetts Institute of Technology, Dept. of Physics, Cambridge, Mass.).

Applied Physics Letters, vol. 8, Feb. 1, 1966, p. 63-65. 5 refs.

NASA-USAF-supported research.

Studies of vibrational and rotational relaxations in the  $\text{CO}_2$  and  $\text{N}_2\text{O}$  laser systems using Q-switching techniques. In addition to lifetime studies, Q switching may also be used for the observation of the decay of the rate of excitation of the laser levels in a pulsed discharge. An important conclusion of the experiment described is that during the time in which the Q switching takes place, thermalization of the rotational levels may be prevented. M. F.

**A66-23357****OBSERVATION OF LASER ACTION IN THE R-BRANCH OF  $\text{CO}_2$  AND  $\text{N}_2\text{O}$  VIBRATIONAL SPECTRA.**

G. Moeller and J. Dane Rigden (Perkin-Elmer Corp., Norwalk, Conn.).

Applied Physics Letters, vol. 8, Feb. 1, 1966, p. 69, 70. 8 refs.

Observation of laser action on all the rotational lines in the  $00^0_1$ - $10^0_0$  and  $00^0_1$ - $02^0_0$  vibrational bands of  $\text{CO}_2$  and in the  $00^0_1$ - $10^0_0$  band of  $\text{N}_2\text{O}$  in both the P and R branches up to J values of over 50 in some cases. The two lines nearest the center of the  $00^0_1$ - $10^0_0$  band of  $\text{N}_2\text{O}$  were not seen. Oscillation was seen on 170 lines, of which at least 120 had not been reported before in the literature. Of the total number of lines, 103 are in  $\text{CO}_2$  and the rest in  $\text{N}_2\text{O}$ . The maximum J numbers observed are tabulated. The technique used to obtain oscillation at all of these wavelengths was to incorporate a wavelength-discriminating device into the laser cavity, thereby removing competition effects. The experimental setup is shown. M. F.

**A66-23432****LASER-INDUCED BREAKDOWN IN OXYGEN GAS AT HIGH PRESSURE.**

T. H. Wiggins, R. V. Wick, D. H. Rank (Pennsylvania State University, Dept. of Physics, University Park, Pa.), and A. H. Guenther (USAF, Systems Command, Weapons Laboratory, Kirtland AFB, N. Mex.).

Applied Optics, vol. 5, Jan. 1966, p. 166, 167.

Navy-supported research.

Outline of an experiment on laser-induced breakdown in oxygen compressed to 395 atm by cryogenic means. The experimental facility consists essentially of a gastight pressure cell, a Korad ruby laser, and a 5-cm focal length lens. The single giant pulse that was emitted by the laser caused a breakdown most probably at the focus of the lens. An oscilloscope measurement of the pulse energy is found to be 0.9 joule with a half-intensity width of about 10 nsec. It is observed visually and verified by spectrograph that the laser light does not pass through the gas cell, since only an intense continuum is observed on the spectrogram. B. B.

**A66-23433****ELECTRON BEAM EXCITATION IN LASER CRYSTALS.**

W. W. Anderson (Stanford University, Stanford, Calif.).

Applied Optics, vol. 5, Jan. 1966, p. 167, 168. 9 refs.

Army-supported research.

Proposal of a method for determining the depth of the active region in laser materials. With this method an estimate of 5 to 7  $\mu$  is obtained for 50-keV electrons in GaAs. The Ehrenberg and King

## A66-23477

data for the mapping of the energy dissipation of electrons passing through a crystal are used. The densities and average atomic numbers of several laser or potential laser semiconductors are listed, and the calculated energy dissipation values for electrons in GaAs, ZnSe, InSb, and ZnS are plotted. B. B.

## A66-23477

### SELECTION OF RAMAN LASER MATERIALS.

Gisela Eckhardt (Hughes Aircraft Co., Research Laboratories, Malibu, Calif.).

IEEE Journal of Quantum Electronics, vol. QE-2, Jan. 1966, p. 1-8. 67 refs.

Contract No. AF 33(657)-11650.

In order to select Raman laser materials for a specific purpose, it is important to know which frequency shifts and excitation power thresholds can be expected from various substances. The thresholds are strongly dependent on the peak scattering cross sections of the corresponding incoherent Raman lines, and these cross sections can vary by several orders of magnitude between Raman lines from different molecules as well as between Raman lines from a single molecule. This paper points out how the rules concerning frequencies, intensities, degrees of depolarization, and linewidths, established for incoherent Raman scattering, can be used as a guide for the prediction of Raman laser performance for new materials. Subsequently, all substances and participating vibrations which have been reported to exhibit stimulated Raman scattering to date are listed and discussed. (Author)

## A66-23478

### PHENOMENA INFLUENCING THE TEMPERATURE BEHAVIOR OF STIMULATED EMISSION IN GaAs P-N JUNCTIONS.

M. F. Lamorte, T. Gonda, and H. Junker (Radio Corporation of America, RCA Electronic Components and Devices Div., Somerville, N. J.).

IEEE Journal of Quantum Electronics, vol. QE-2, Jan. 1966, p. 9-15. 11 refs.

Contract No. DA-44-009-AMC-99(T).

The decrease of internal efficiency with increasing temperature in injection lasers has been assumed in the past to be responsible for the increase in threshold and the decrease in external efficiency. This decrease in internal efficiency has been attributed to the greater hole-electron smearing, with a consequent reduction of the degree to which inverted population occurs in the region in which stimulated emission takes place. This paper shows that the increase in hole and electron smearing which occurs at elevated temperatures has a negligible influence in degenerate GaAs laser diodes in contrast to the greater optical loss arising from p-region absorption. It is demonstrated that the increase in threshold is due to the stronger p-type absorption at 300°K. On this basis, it is also shown that the threshold current ratio  $J_{th}(300^\circ K)/J_{th}(77^\circ K)$  ranges from 12 to 20.0. This range is in agreement with experimental values. In this calculation the internal quantum efficiency is assumed to remain constant in the temperature range from 77 to 300°K. The laser linewidth increases from 0.75 Å at 77°K to 5 Å at 300°K. In addition, there is a corresponding increase in apparent mode spacing. These data indicate that the cavity Q decreases by approximately one order of magnitude from 77 to 300°K. The correspondence between the cavity Q and the threshold is shown. Calculated and experimental ratio values of threshold and cavity Q are shown employing absorption data for GaAs in the literature. As further confirmation, curves of threshold, linewidth, and cavity Q with temperature are all shown to have the same shape. The data presented and the calculations made on the assumed model show that the p-type absorption loss is the dominant mechanism in increasing threshold in degenerate junctions and that hole-electron smearing is negligible. (Author)

## A66-23479

### EFFICIENT HIGH ENERGY LASER RADIATION UTILIZING A COAXIAL OPTICAL PUMP.

J. P. Lesnick and C. H. Church (Westinghouse Electric Corp., Research Laboratories, Pittsburgh, Pa.).

IEEE Journal of Quantum Electronics, vol. QE-2, Jan. 1966, p. 16, 17.

Contract No. DA-36-034-AMC-0293(Z).

Account of the efficient conversion of electrical energy into laser radiation achieved using a coaxial flash lamp as an optical pump and laser rods consisting of neodymium-doped silicate glass rod 941 mm long and 18 mm in diameter. Coaxially and linearly pumped laser outputs are tabulated and a sketch is presented of a coaxial laser pump showing laser rod and end windows in place. One of the questions that arises in the use of the coaxial geometry is the uniformity with which the arc fills the arc channel. Photographs indicated that the coaxial arc channel was uniformly filled at an energy density as low as 10 joules/cm<sup>3</sup> for a 500 μsec pulse length. M. F.

## A66-23667 #

### THEORY OF SINGLE-PULSE OPERATION OF LASERS [O TEORII MONOIMPUL'SNOGO REZHIMA RABOTY OPTICHESKIKH KVANTOVYKH GENERATOROV].

Iu. A. Anan'ev, I. F. Balashov, and A. A. Mak.

Akademii Nauk SSSR, Doklady, vol. 166, Feb. 1, 1966, p. 825-828. 9 refs. In Russian.

Analysis of single-pulse operation of lasers, taking into account the process of energy storage in the active medium. It is found that the amplification effect of spontaneous emission is very great in the case of four-level active media and that the maximum power is limited precisely by this factor. In the case of a three-level active medium the main factor limiting the maximum radiation power for the given laser parameters is found to be brightening of the active medium. A. B. K.

## A66-23716

### CW MEASUREMENT OF THE OPTICAL NONLINEARITY OF AMMONIUM DIHYDROGEN PHOSPHATE.

G. E. Francois (Stanford University, Dept. of Electrical Engineering, Stanford, Calif.).

Physical Review, 2nd Series, vol. 143, Mar. 11, 1966, p. 597-600. 17 refs.

Contracts No. AF 49(638)-1525; No. AF 33(657)-11144.

We have measured the value of the element  $d_{36}$  of the nonlinear dielectric tensor of ammonium dihydrogen phosphate for the doubling of the 6328-Å line of the He-Ne laser. Two measurements were made. The first used a collimated single-transverse-mode laser beam (focal spot radius  $\approx 0.2$  cm) containing several longitudinal modes. The second used a weakly focused single-mode and single-frequency laser (focal spot radius  $\approx 0.03$  cm). In both experiments the crystal was slowly rotated through the index-matching angle. The value of  $d_{36}$  obtained by either method is  $1.36 \times 10^{-9}$  ( $\pm 12\%$ ) in cgs esu. The experiments also verify the factor  $(2n-1)/n$  for the enhancement of second-harmonic generation when  $n$  independent longitudinal modes are present. (Author)

## A66-23731 #

### COMMENTS ON BEAM MASER TYPE SPECTROMETERS USING COHERENTLY RADIATING STATES.

D. C. Lainé (Keele, University, Dept. of Physics, Keele, Staffs., England).

Physical Society, Proceedings, vol. 87, Mar. 1966, p. 855-857. 16 refs.

It is pointed out that the technique used by Dicke and Rorner of pulse excitation of a volume of gas to a coherently radiating state can be applied to high-resolution spectroscopy using molecular beams. A two-cavity maser-like system without a state separator is proposed, where the molecular beam is polarized by a pump field in the first cavity and the coherent spontaneous emission radiated in a second pick-up cavity detected by a superheterodyne receiver. (Author)

**A66-23759****USING PHOTOMULTIPLIERS FOR LASER RANGING.**

Jack Rogers.

Electronic Industries, vol. 25, Mar. 1966, p. 72, 73.

Study of the use of digital counting methods in laser rangefinders to find range. A laser rangefinder facility is described and illustrated schematically, and its operation is explained. The photomultiplier tube (PMT), dynode biasing, effective photocathode diameter, and the output coupling circuit are discussed. A schematic diagram is given of the equivalent hf output circuit for the photomultiplier tube.

B. B.

**A66-23778 #****LASER RADIATION FIELD FOCUSED BY REAL SYSTEMS [POLE LAZERNOGO IZLUCHENIYA, SFOKUSIROVANNOE REAL'NYMI SISTEMY].**

B. Ia. Zel'dovich and N. F. Pilipetskii (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR).

Radiofizika, vol. 9, no. 1, 1966, p. 95-101. 10 refs. In Russian.

Calculation of the absolute value of the spatial amplitude of the field of an ideally parallel laser beam focused by optical systems with spherical aberration. Expressions are derived to determine a laser radiation field with high, arbitrary aberration, dismissing the vectorial character of the electromagnetic field. For a given beam diameter and a given lens, the existence of an optimum focal length with a maximum local value of the radiation field is suggested. The conic length is discussed as a means for producing an extended beam filament with a strong field and a stable effective wave vector. Vectorial synchronism in nonlinear optics is realized by means of a conical lens.

V. Z.

**A66-23931 #****RECENT APPLICATIONS OF LASERS.**O. S. Heavens (York, University, Dept. of Physics, York, England). British Journal of Applied Physics, vol. 17, Mar. 1966, p. 287-309. 99 refs.

A summary is given of the performances of lasers reported to date and an outline is given of some of the techniques which are now being applied to the operation of lasers. Some of the less well-known methods which have been developed for the control of laser systems are discussed. A review is given of progress in the application of lasers in the following fields: amplification, modulation, interferometry, diffractometry, scattering (Brillouin, Raman, and Rayleigh), plasma diagnostics, nonlinear optics, high-field effects, biology and medicine. While the review is not in any sense comprehensive, it is aimed at giving a representative illustration of the areas to which laser techniques can contribute.

(Author)

**A66-23946 #****RED GAS LASER [CZERWONY LASER GAZOWY].**F. Kaczmarek, H. Dymaczewski, Z. Błaszczak (Poznań, Uniwersytet, Katedra Fizyki Doświadczalnej, Poznań, Poland). Postępy Fizyki, vol. 17, no. 1, 1966, p. 71-79. 12 refs. In Polish.

Brief review of the principles of operation of the He-Ne laser ( $\lambda = 6328 \text{ Å}$ ). Some Polish-made He-Ne lasers are described. Their power outputs, measured as a function of the total gas pressure, the He/Ne ratio, and the mirror transmission coefficient, are given. The maximum power output obtained from an He-Ne laser was 7 mw. Applications of the He-Ne laser in interferometry are illustrated by photographs of interference fringes.

V. P.

**A66-23960 #****PARAMETER DEPENDENCE OF I. F. VOLTAGE IN OPTICAL MIXERS.**

K. S. Cho, H. F. Mataré, and A. H. Solomonian (Douglas Aircraft Co., Inc., Missile and Space Systems Div., Advance Electronics Dept., Santa Monica, Calif.).

International Journal of Electronics, First Series, vol. 19, Dec. 1965, p. 549-554.

Study of the parameter dependence of the i. f. voltage while establishing the optimum conditions for optical receivers and assessing the merit of subcarrier mixing. The results measured are found in good agreement with the theory.

M. F.

**A66-24009****CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION.**

V. S. Vavilov and E. L. Nolle (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(Akademiia Nauk SSSR, Doklady, vol. 164, Sept. 1, 1965, p. 73, 74.)Soviet Physics - Doklady, vol. 10, Mar. 1966, p. 827, 828. 10 refs. Translation.

[For abstract see issue 01, page 84, Accession no. A66-11188]

**A66-24010****ILLUMINATION OF A BUBBLE CHAMBER USING A RUBY LASER.**

V. S. Gorbunkov, V. V. Korobkin, and A. M. Leontovich (Akademiia Nauk SSSR, Fizicheskii Institut, Moskovskii Fiziko-Tekhnicheskii Institut, Moscow, USSR).

(Akademiia Nauk SSSR, Doklady, vol. 164, Sept. 1, 1965, p. 75-77.)Soviet Physics - Doklady, vol. 10, Mar. 1966, p. 829-831. 8 refs. Translation.

[For abstract see issue 01, page 84, Accession no. A66-11189]

**A66-24011****CONTINUOUS OPERATION OF A GaAs INJECTION LASER COOLED BY A FLOW OF GASEOUS HELIUM.**

M. N. Zargar'iants, A. A. Kiselev, O. D. Kropotova, L. N.

Kurbatov, Iu. M. Liustrov, V. V. Sigriianskii, I. I. Taubkin, and I. P. Shestopalova.

(Akademiia Nauk SSSR, Doklady, vol. 164, Sept. 1, 1965, p. 78, 79.)Soviet Physics - Doklady, vol. 10, Mar. 1966, p. 832, 833.

Translation.

[For abstract see issue 01, page 84, Accession no. A66-11190]

**A66-24124****THE OPTICALLY PUMPED RUBIDIUM MASER.**

P. Davidovits (Yale University, Dept. of Applied Science and Engineering, New Haven, Conn.) and R. Novick (Columbia University, Columbia Radiation Laboratory, New York, N.Y.).

IEEE, Proceedings, vol. 54, Feb. 1966, p. 155-170. 63 refs.

Contract No. DA-28-043-AMC-00099(E); No. Nonr-4259(10).

Description of the physical principles and construction of an optically pumped rubidium maser oscillator which is small and simple enough to be considered as a replacement for crystal oscillators. The maser consists of a microwave cavity filled with Rb87 vapor and nitrogen gas; its power output is 10-10 watt. The effects of optical pumping, buffer gas, and temperature on the maser are discussed, and experimental results are given. The short-term stability for observation times of about 1 sec is expected to be about one part in  $10^{12}$ . The long-term stability is expected to be comparable to that obtained in the passive rubidium standard. It is claimed that the long-term stability can be improved by using the rubidium maser as a flywheel for an atomic beam frequency standard.

B. B.

**A66-24128****THE SPECIFICATION OF OSCILLATOR CHARACTERISTICS FROM MEASUREMENTS MADE IN THE FREQUENCY DOMAIN.**

R. Vessot, L. Mueller, and J. Vanier (Varian Associates, Beverly, Mass.).

IEEE, Proceedings, vol. 54, Feb. 1966, p. 199-207. 18 refs.

Contract No. NAS 8-2604.

A cross-correlation technique for measuring the very short-term (milliseconds to seconds) properties of stable oscillators is described. Time-dependent functions representing signals from two separate oscillators are led to a function multiplier where the instantaneous product of the functions is made. The oscillators are either set to a given phase relation or allowed a small relative drift so that a slow beat frequency is observed. Short-term fluctuations superimposed upon the slow beat signal from the multiplier output will represent the instantaneous phase difference between the oscillators when the inputs are in quadrature. When the inputs are in and

## A66-24130

out of phase, the fluctuations represent amplitude fluctuations. The time averaging function is determined by a filter having a rectangular pass band from nearly zero frequency to a cutoff frequency  $\nu_c$ . The mean square frequency deviation measured in a bandwidth  $\omega_c$  is obtained by differentiating, filtering, squaring, and averaging the signal from the function multiplier data being taken when the input signals are in quadrature. Mean square averages of amplitude and phase averaged over various bandwidths  $\omega_c$  may be obtained by bypassing the differentiator. Sample data from measurements on hydrogen masers are presented, and the effect of thermal noise is seen to be the major factor limiting the short-term frequency stability of the signals.

(Author)

## A66-24130

### STATISTICS OF ATOMIC FREQUENCY STANDARDS.

David W. Allan (National Bureau of Standards, Boulder, Colo.).

IEEE, Proceedings, vol. 54, Feb. 1966, p. 221-230. 12 refs.

A theoretical development is presented which results in a relationship between the expectation value of the standard deviation of the frequency fluctuations for any finite number of data samples and the infinite time average value of the standard deviation, which provides an invariant measure of an important quality factor of a frequency standard. A practical and straightforward method of determining the power spectral density of the frequency fluctuations from the variance of the frequency fluctuations, the sampling time, the number of samples taken, and the dependence on system bandwidth is also developed. Additional insight is also given into some of the problems that arise from the presence of "flicker noise" (spectrum proportional to  $|\omega|^{-1}$ ) modulation of the frequency of an oscillator. The theory is applied in classifying the types of noise on the signals of frequency standards made available at NBS, Boulder Laboratories, such as: masers (both H and  $\text{N}^{15}\text{H}_3$ ), the cesium beam frequency standard employed as the U.S. Frequency Standard, and rubidium gas cells. "Flicker noise" frequency modulation was not observed on the signals of masers for sampling times ranging from 0.1 sec to 4 hr. In a comparison between the NBS hydrogen maser and the NBS III cesium beam, uncorrelated random noise was observed on the frequency fluctuations for sampling times extending to 4 hr; the fractional standard deviation of the frequency fluctuations were as low as 5 parts in  $10^{12}$ . (Author)

## A66-24145

### A DIRECT FREQUENCY COMPARISON OF HYDROGEN MASERS IN SEPARATE LABORATORIES BY CONCURRENT MONITORING OF LORAN C SIGNALS.

R. Vessot, L. Mueller, H. Peters, J. Vanier (Varian Associates, Beverly, Mass.), D. Kleppner, and B. Mathur (Harvard University, Cambridge, Mass.).

IEEE, Proceedings, vol. 54, Feb. 1966, p. 303, 304.

NSF-NASA-supported research.

Method for testing the absolute frequency reproducibility of an atomic hydrogen maser by comparing two masers operating in different laboratories under different conditions. The masers differed in many respects, such as technique of wall coating, storage-bulb size, and vacuum-system design; one was operated by a group in Beverly, Mass., and one by a group in Cambridge, Mass. The comparison was made by simultaneously monitoring the Loran C signal from Nantucket Island, Mass., during the period from 0000 to 2400 EST, Nov. 11, 1964. Both groups made a determination of the apparent frequency of the hydrogen masers in terms of the Loran C 100-kc signal. Corrections were made to the measured maser frequencies to refer the operation to given conditions: (1) magnetic field - zero, (2) temperature -  $40^\circ\text{C}$ , (3) wall shift - F.E.P. Teflon in a 5.7-in.-diam bulb, (4) cavity mistuning - zero. The results of the measurements made at the two laboratories differ by 0.0013 cps - about one part in  $10^{12}$ . It is considered that this represents good agreement and that within the resolution of the experiment there is no significant difference between the masers. R. A. F.

## A66-24153

### A BALANCED MIXER FOR OPTICAL HETERODYNING - THE MAGIC T OPTICAL MIXER.

Tom Waite (North American Aviation, Inc., Autonetics Div., Anaheim, Calif.).

IEEE, Proceedings, vol. 54, Feb. 1966, p. 334, 335. 13 refs.

Demonstration of the possibility of obtaining balanced mixer action while heterodyning at optical frequencies, by using Magic-T configurations. It is shown that if a beamsplitter is designed to work as a short, lossless interferometer, the required phase differences and balanced mixer action will occur automatically - independent of wavelength, polarization, angle of incidence, beamsplitter structure, and composition.

R. A. F.

## A66-24224 #

### EFFECT OF A LONGITUDINAL MAGNETIC FIELD ON THE PERFORMANCE OF A HELIUM-NEON LASER WITH A WAVELENGTH OF $0.6328\mu$ (VLIJANIE PRODOL'NOGO MAGNITNOGO POLIA NA RABOTU GELI-NEONOVOGO LAZERA S DLINOI VOLNY IZLU-CHENIJA $\lambda = 0.6328\text{ MK}$ ).

D. K. Terekhin and S. A. Fridrikhov (Leningradskii Politekhni-cheskii Institut, Leningrad, USSR).

Zhurnal Tekhnicheskoi Fiziki, vol. 36, Feb. 1966, p. 394-397.

8 refs. In Russian.

Experimental study of the effect of a longitudinal magnetic field, varied from 0 to 2000 oe, on the nature of the gas discharge, the Zeeman effect, and the Faraday effect in an He-Ne plasma. Various theories are considered that seek to explain the observed initial stimulation of radiation at  $0.6328\mu$ , followed by a decline and final complete emission breakdown. V. Z.

## A66-24312

### A NEW TYPE OF SUPERCONDUCTING MAGNET FOR TRAVELING-WAVE MASERS.

B. J. Walker (Department of Defense, Washington, D. C.).

IEEE, Proceedings, vol. 54, Jan. 1966, p. 96, 97.

Description of an experimental model of a new type of superconducting magnet designed primarily for use with traveling-wave masers. The magnet is claimed to be lighter in weight and easier to fabricate than the more conventional gap-shielded, cyclotron-type magnet. The gap-shielded magnet utilizes a relatively heavy ferromagnetic symmetrical return path and a superconducting shield to prevent fringing in the air gap. The magnet presently described eliminates the ferromagnetic return path but includes a superconducting shield to obtain the required spatial homogeneity in the air gap. A cross-sectional sketch and a photograph of the device are included. The shield is an Nb-Ti alloy about 0.030 in. thick; two pieces of 1/16-in. thick aluminum plate serve as backing for the Nb-Ti sheets, and each polepiece is wound with 800 turns of 0.005-in.-diam Nb-25% Zr wire coated with 0.001-in. thick copper and 0.001-in. nylon. It is found that spatial homogeneity of the magnetic field in the air gap is quite good. A recently developed, wide tuning range L-band traveling-wave maser has been operated in the magnet. M. L.

## A66-24395

### BACKSCATTERING FROM THE UPPER ATMOSPHERE (75-160 KM) DETECTED BY OPTICAL RADAR.

P. D. McCormick, S. K. Poultney, U. Van Wijk, C. O. Alley, R. T. Bettinger (Maryland, University, Dept. of Physics and Astronomy, College Park, Md.), and J. A. Perschy (Johns Hopkins University, Applied Physics Laboratory, Silver Spring, Md.).

Nature, vol. 209, Feb. 19, 1966, p. 798, 799.

Grant No. WBG-4-FY-64; ARPA Grant No. SD-101; Grant No. NGR-21-002-022; Contract No. NOBR-72710.

Experimental study of backscattering from the upper atmosphere (75 to 160 km) using an optical radar system. The optical radar consists of a Korad K-2Q ruby laser capable of producing single pulses of 6 to 10 joules at  $6943\text{Å}$  with a width of 10 nsec and a beam divergence of no more than 10 milliradians. Results are presented based on measurements made at College Park, Md. ( $76^\circ 57' \text{ W.}$ ,  $39^\circ \text{ N.}$ ), while looking at the zenith. A 20-in. Broken Cassegrain with a 300-in. effective focal length was used. Although a more detailed investigation is proceeding, preliminary findings seem to indicate rough agreement with those of Fiocco and Smullin, who suggested micrometeorites as a source of the echoes. The

return signal, when averaged over several hours, tends to become relatively smooth, and it would therefore seem that the altitudes of the scattering layers, if they exist, fluctuate rapidly with time.

M. L.

**A66-24413****FOCUSED ENERGY TECHNIQUES FOR JOINING - INCLUDING LASER WELDING.**

Maurice Nelles (Westinghouse Electric Corp., Atomic, Defense and Space Group, Aerospace Div., Baltimore, Md.).  
American Society of Tool and Manufacturing Engineers, and American Society for Metals, Western Metal and Tool Conference, Los Angeles, Calif., Mar. 7-11, 1966, Preprint AD66 - 718. 5 p.

Members, \$0.75; nonmembers, \$1.00.

Discussion of focused energy techniques for joining, including most of the techniques created and developed during the past twenty years. Developments of diffusion bonding methods, including ultrasonic bonding, are the principal exceptions. Emphasis is placed on lasers because their application to manufacturing joining technology is not so well defined as for electron beams. Recent innovations in electron beam technology are considered as well as new developments in the use of focused plasma beams.

M. M.

**A66-24415****SELECTING A LASER WELDER FOR PRODUCTION MICRO-WELDING.**

Lester J. Martin (Hughes Aircraft Co., Advanced Technology Group, Materials and Processes Section).

American Society of Tool and Manufacturing Engineers, and American Society for Metals, Western Metal and Tool Conference, Los Angeles, Calif., Mar. 7-11, 1966, Preprint MM66 - 707. 8 p. 10 refs.

Members, \$0.75; nonmembers, \$1.00.

Discussion of the practicality of using laser welding for small microwelds on a production basis. Features and considerations of laser welders are discussed to give the design and process engineer a starting basis on which to select a machine to meet production requirements.

M. M.

**A66-24455 \*****ASYMMETRY IN THE EXCITATION OF OSCILLATION MODES IN SEMICONDUCTOR LASERS. АСИММЕТРИЯ ВОЗБУЖДЕНИЯ ТИПОВ КОЛЕБАНИЙ В ПРОВODНИКОВЫХ ЛАЗЕРАХ].**

O. N. Kravchenko and V. Uspenskii (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

Fizika Tverdogo Tela, vol. 8, Feb. 1966, p. 511-514. In Russian.

Analysis of the excitation of axial oscillation modes in semiconductor lasers, on the basis of the rate equations for the chemical potentials of the carriers and the number of photons. Allowance is made for the change in the amplification factor and its spectral shape as a function of the degree of inversion. It is shown that this dependence leads to asymmetric excitation of axial modes of oscillation; for some semiconductor parameters, the asymmetry may be only slight.

V. P.

**A66-24498 \*****SOME APPLICATIONS OF THE LASER AS AN ATMOSPHERIC PROBE.**

Frank W. Gibson (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Aerospace Instrumentation Laboratory, Bedford, Mass.).

American Meteorological Society and American Institute of Aeronautics and Astronautics, Conference on Aerospace Meteorology, Los Angeles, Calif., Mar. 28-31, 1966, Paper 66-374. 16 p. 9 refs. Members, \$0.75; nonmembers, \$1.50.

Investigations are being conducted to determine the possibility of detecting clear air turbulence (CAT) with laser optical radars. Experiments in the laboratory and afield have shown evidence of

variations in particle concentrations, but no positive identification of turbulence or correlates of rough flying have been made. The feasibility of measuring wind velocity components with a laser Doppler radar is being examined. Provided sufficient aerosol scattering is available, spectral frequency analysis should give a more direct measurement of turbulence. A laser searchlight technique has been used to measure atmospheric density vertically up to 60 km. The method uses Rayleigh scattering theory to deduce the molecular number density from the number of backscattered photons detected.

(Author)

**A66-24559****PARAMETRIC INTERACTIONS OF OPTICAL MODES.**

Amnon Yariv (California Institute of Technology, Div. of Engineering and Applied Science, Pasadena, Calif.).

IEEE Journal of Quantum Electronics, vol. QE-2, Feb. 1966, p. 30-37. 24 refs.

Contract No. AF 33(615)-2800.

Derivation of the equations of motion governing the interaction of optical modes in the presence of time-varying parameters. A formalism of normal modes which results in concise and symmetric formulation of the problem is developed. Two general types of modulation are considered - modulation of the dielectric constant and modulation of the losses. Some well-known cases, such as parametric oscillation and internal mode-locking in laser oscillators, are treated, and some new interactions involving loss modulation and dielectric modulation in the presence of negative losses are considered.

R. A. F.

**A66-24560****ANALYSIS OF THE UNIFORM RATE EQUATION MODEL OF LASER DYNAMICS.**

Thomas J. Menne (McDonnell Aircraft Corp., St. Louis, Mo.).

IEEE Journal of Quantum Electronics, vol. QE-2, Feb. 1966, p. 38-44. 24 refs.

The spatially independent laser rate equation model is generalized to include multimode effects, and it is also shown that the same description of laser behavior as provided by the single-mode model results. Analytical expressions for the steady-state values of the variables in all modes are derived. It is shown that a singularity at the oscillation threshold exists in the steady-state equations which is responsible for the laser action. It is further demonstrated that the inverted population and the photon density in off-axis modes saturates above threshold, whereas the photon density in the primary mode increases with pump rate above threshold. The exact time-dependent solutions are determined numerically, and it was found that the spiking separation and decay time could change by more than 50% of their values at the start of laser emission to the region of steady-state oscillation, even when the pump is assumed to be time independent. The linearized expressions for the spiking parameters are, therefore, inadequate - despite their frequent use - to describe phenomena appearing in the early portions of the spiking trace. A comparison with five experimental cases is also made. It was found that this model, with all modes included, provides no improvement over the single mode model, and cannot account for the irregular or undamped spiking or even the multimode oscillations observed experimentally.

(Author)

**A66-24562****EFFECT OF SPATIAL DEPENDENCE IN THE SINGLE-MODE LASER RATE EQUATIONS.**

T. J. Menne and F. J. Rosenbaum (McDonnell Aircraft Corp., St. Louis, Mo.).

IEEE Journal of Quantum Electronics, vol. QE-2, Feb. 1966, p. 47-49. 10 refs.

Determination of the steady-state value of the inverted population, power output, threshold behavior, and spiking characteristics for a single-mode laser when the radiation intensity has spatial dependence. It is found that the nonuniform population difference at the nodes of the radiation field and the output power exceed the values obtained above threshold in the case of a uniform intensity; the other quantities are unchanged.

R. A. F.

**A66-24568**

MODEL OF INTERACTING RADIATION AND MATTER. III - MULTIMODE GAS LASERS.  
Charles R. Willis (Boston University, Boston, Mass.).  
*Journal of Mathematical Physics*, vol. 7, Feb. 1966, p. 404-412.  
5 refs.

USAF-sponsored research.

We extend the investigation of the long-time behavior of a model consisting of  $N$  two-level atoms interacting with a single electromagnetic cavity mode to include interaction with many cavity modes. We show that, as a consequence of the coupling between radiation modes produced by spatial density variations of the population inversion, there is no strictly stationary state possible for multimode behavior. However we obtain a stationary state by neglecting the rapidly oscillating terms. The steady-state population inversion is then a solution of an eigenvalue problem. The eigenvalue determinant is a function of the number of modes and the coupling between modes in addition to the usual dependence on frequencies and relaxation times. We explicitly solve for the unique eigenvalue in special cases. The corresponding eigenvector gives the steady-state mode intensity ratios. The absolute values of the steady-state intensities are determined by the energy conservation equation generalized to include pumping and dissipation. We also calculate the steady-state frequency shifts for each mode. The mode frequency shifts are practically independent of each other and have the same functional form as the single-mode frequency shifts. (Author)

**A66-24881 #**

DISCRIMINATION OF AXIAL MODES IN A LASER WITH EXTERNAL MIRRORS [DISKRIMINATSIIA AKSIAL'NYKH TIPOV KOLEBANIY V LAZERE S VNESHNIMI ZERKALAMI].

V. I. Malyshev and A. S. Markin (Akademiya Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 50, Feb. 1966, p. 339-342. 8 refs. In Russian.

Investigation of the dependence of the beat frequency of the axial modes of a neodymium laser on the distance between the mirrors and the position of the neodymium rod within the resonator. It is shown that the beat frequency varies with a variation in the position of the neodymium rod. The observed phenomenon is attributed to discrimination of axial modes due to variation of the parameters of the complex resonator formed by the external mirrors and the ends of the neodymium rod.

A. B. K.

**A66-24884 #**

PULSED INDUCED EMISSION IN A HYDROGEN-BEAM LASER [IMPUL'SNOE INDITSIROVANNOE IZLUCHENIE V KVANTOVOM GENERATORE NA PUCHKE ATOMOV VODORODA].

G. M. Strakhovskii and A. V. Uspenskii (Akademiya Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 50, Feb. 1966, p. 372-375. In Russian.

Consideration of pulsed induced emission in a hydrogen-beam laser for the case of two relaxation times. It is shown that if a number of conditions are met, the polarization excited in the laser by the pumping pulse is determined only by the number of active particles in the resonator, while the damping of the induced signal occurs according to an exponential law with the exponent  $1/T_2$ , where  $T_2$  is the longitudinal relaxation time.

A. B. K.

**A66-24885 #**

DEPENDENCE OF THE EMISSION INTENSITY OF A GAS LASER ON THE MAGNETIC FIELD STRENGTH [O ZAVISIMOSTI INTENSIV-NOSTI IZLUCHENIIA GAZOVOGO LAZERA OT MAGNITNOGO POLYA].

M. I. D'iafonov and V. I. Perel' (Akademiya Nauk SSSR, Fiziko-Tekhnicheskii Institut, Leningrad, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 50, Feb. 1966, p. 448-456. 9 refs. In Russian.

Consideration of the dependence of the emission intensity of a gas laser on the longitudinal and transverse magnetic fields. In the proposed simplified model the area of the holes burnt in the amplification line is found to be proportional to the intensity. It is shown that the emission intensity possesses a minimum for a zero magnetic

field and also when the Zeeman level splitting is equal to the resonator detuning. It is further shown that a minimum intensity may also occur in a transverse magnetic field when the Zeeman splitting is equal to twice the resonator detuning. The intensity minima are interpreted as being the result of merging of the holes in the amplification line. It is found that a nonmonotonic dependence of the generation frequency on the magnetic field may also occur when the holes merge.

A. B. K.

**A66-24887 #**

SOME ASPECTS OF THE MECHANISM OF A LUMINOUS DISCHARGE IN A GAS [K VOPROSU O MEKHANIZME SVETOVOGO PROBOIA V GAZE].

V. A. Barynin and R. V. Khokhlov (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 50, Feb. 1966, p. 472, 473. 5 refs. In Russian.

Brief discussion of a gas discharge induced by a laser pulse. The theory of the phenomenon is revised to account for the photo-ionization of molecules excited in collisions with electrons. The revised version provides a better agreement with experimental results.

V. Z.

**A66-24888 #**

THEORY OF GENERATION OF OPTICAL HARMONICS IN CONVERGING BEAMS [K TEORII GENERATSII OPTICHESKIKH GARMONIK V SKHODIASHCHEKHSIA PUCHKAKHI].

S. A. Akhmanov, A. P. Sukhorukov, and R. V. Khokhlov (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR).

*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, vol. 50, Feb. 1966, p. 474-486. 11 refs. In Russian.

Development of a consistent theory of nonlinear optical effects in bounded beams of light, using as a basis the method of parabolic equations extended to nonlinear problems. This approach permits an effective analysis of nonlinear wave behavior with a first-approximation allowance for diffraction. The problem of generation of the second harmonic of a gently converging cylindrical wave in an anisotropic medium is discussed. The intensity and spatial structure of the harmonic are determined. Fair agreement of theory and experiment is noted.

V. Z.

**A66-24898 #**

TREATMENT OF STEEL WITH A LASER BEAM [OBRABOTKA STALI LUCHOM LAZERA].

A. N. Kokora, A. A. Zhukov, V. A. Shalashov, E. N. Liumarov, M. P. Kalianova, and V. A. Belianin (Vsesoiuznyi Nauchno-Issledovatel'skii Institut Lekhkhogo i Tekstil'nogo Mashinostroeniia, Moscow, USSR).

*Metallovedenie i Termicheskaya Obrabotka Metallov*, Feb. 1966, p. 41, 42. In Russian.

Discussion of attempts to obtain precision holes in 0.22-mm steel plates by  $10^{-3}$  sec exposure to a 0.5-joule plasma beam. The microhardness of the metal in the exposed area is found to be only slightly affected. Data obtained suggest that a laser beam produces a local hardening effect.

V. Z.

**A66-25018**

CORRELATION FUNCTION OF THE AMPLITUDE AND OF THE INTENSITY FLUCTUATION FOR A LASER MODEL NEAR THRESHOLD.

H. Risken (Stuttgart, Technische Hochschule, Institut für theoretische und angewandte Physik, Stuttgart, West Germany).

*Zeitschrift für Physik*, vol. 191, no. 3, 1966, p. 302-312. 7 refs.

Research supported by the Deutsche Forschungsgemeinschaft.

Calculation of the correlation functions of the amplitude and the intensity fluctuation for a laser model in the threshold region. The laser amplitude is treated as a classical random variable obeying a Van der Pol equation with a noise term. The correlation functions are obtained by using distribution functions evaluated with the aid of the Fokker-Planck equation. The lowest eigensolutions of the Fokker-Planck equation are obtained approximately by a variational method.

A. B. K.

# 1966

## LC ENTRIES

A66-80961

LASER AND THE LABYRINTH: SOME PRELIMINARY EXPERIMENTS ON PIGEONS.

J. Stahle and L. Högberg (Uppsala U., Dept. of Otolaryngol. and Dept. of Phys., Sweden).

*Acta Oto-Laryngologica*, vol. 80, Oct. 1965, p. 367-374. 19 refs.

The inner ears of pigeons were irradiated by means of a Q-switched ruby laser with an output pulse energy of about 0.3 joule. Atrophy of the epithelium and changes in the bony and membranous labyrinth were observed. The ability of the laser beam to penetrate thin slices of bone was tested. The biological effect of the laser beam seems to be mainly thermal, but ultrasonic waves created in the focal spot may contribute.

A66-80011

LASER IRRADIANCE LEVELS FOR RETINAL LESIONS.

Tore Bergquist, Bengt Kleman (Res. Inst. of the Natl. Defence, Phys. Dept., Stockholm, Sweden), and Björn Tengroth (Sahlgren Hosp. Gothenburg S.V., Univ. Gothenburg, Dept. of Ophthalmol., Sweden).

*Acta Ophthalmologica*, vol. 43, 1965, p. 331-349. 22 refs.

The action of laser radiation on rabbit eyes has been studied with four different ruby lasers and two Nd-glass lasers. The output of the lasers varied from a burst of pulses with a duration of 650  $\mu$ s to a single pulse with a width of 35 ns. It has been found that with these lasers with widely different output characteristics there is a common threshold value in the peak irradiance at which lesions occur. The threshold refers to the irradiance level at which minimal lesions start to appear, as observed in an ophthalmoscope immediately after the irradiation. The threshold value for the peak corneal irradiance was about 6  $\text{kWcm}^{-2}$  when the rabbit's eye was in the direct beam at a short distance from the laser. This corresponds for ruby lasers to a threshold value in the peak retinal irradiance of 170  $\text{MWcm}^{-2}$ . The results from these experiments are in good agreement with the results from a few cases of irradiation of human eyes. Various aspects of hazards of laser radiation to the human eye are considered. As yet there are relatively few papers in the literature dealing with problems concerning hazards to the eye of laser radiation.

A66-80470

THE EFFECT OF LASER RADIATION ON THE RETINAL VASCULATURE: ANIMAL AND CLINICAL STUDIES.

Francis A. L'Esperance, Jr. (Columbia-Presbyterian Med. Center, Inst. of Ophthalmol., New York City, N. Y.)

(AMA, 114th Ann. Meeting, New York City, Jun. 20-24, 1965).

*Archives of Ophthalmology*, vol. 74, Dec. 1965, p. 752-759. 12 refs.

Experimental evidence indicates that the effect of laser radiation on the retinal vasculature depends upon the proximity of the pigment epithelium or melanocytes to the blood vessel, the rate of blood flow, the amount of reduced hemoglobin present, and the intensity of the incident beam. Elevated areas of neovascularization and large retinal angiomas were not effectively treated during the one-year study. Most microaneurysms, a small percentage of the flat areas of neovascularization, and retinal angiomas less than two disc diameters in size were obliterated by the coagulation effect of laser radiation.

A66-80950

CHORIORETINAL LESIONS PRODUCED BY LASER ON MONKEYS AND RABBITS.

Raúl Santos, and Sadi de Buen (Mexico U. Med. School, Dept. of Histol. and Mex. Registry of Pathol., Mexico City), and Robert K. Abraham (Calif. Coll. of Med., Dept. of Surg., Ophthalmol. Sect., Los Angeles).

*American Journal of Ophthalmology*, vol. 61, Feb. 1966, p. 230-240.

Optica Lux and David Michael Eye Found. supported research.

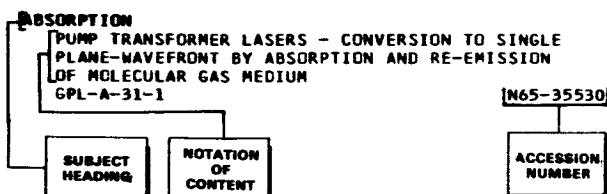
A ruby laser with a direct ophthalmoscope head was used to produce/chorioretinal lesions in 10 monkeys and 50 rabbits. The energy output varied from 0.01 to 0.03 joule. The beam divergence channel from 4.5 to 90 milliradians. The chorioretinal lesions obtained in monkeys showed a variety of intensities and a close similarity to the reactions of human eyes. By controlling the energy output and divergence, it was possible to obtain clinically useful lesions. Histologic study showed chorioretinal adhesion with no disturbance of the vitreous in lesions of medium intensity. Rabbit eyes proved more sensitive; threshold intensities always produced chorioretinal lesions. Alteration of the pigment epithelium was a constant finding in all cases. The characteristics of the lesion were those of a thermal burn. It was not possible to prove any other effect, a has been suggested for high energy lasers. Long-range studies are required to rule out late effects. In the selected human cases of retinal detachment treated, a follow-up of four months showed that satisfactory results were obtained.

# Subject Index

**LASERS AND MASERS** / a continuing bibliography with indexes

JULY 1966

## Typical Subject Index Listing



A Notation of Content (NOC), rather than the title of the document, is used to provide a more exact description of the subject matter. In order to provide the user with more than one approach in the search for specific information, a subject may be listed under several subject headings. The accession number is included to assist the user in locating the abstract in the abstract section.

## A

### ABERRATION

SPATIAL AMPLITUDE OF FIELD OF IDEALLY PARALLEL LASER BEAM FOCUSED BY OPTICAL SYSTEMS WITH SPHERICAL ABERRATION A66-23778

### ABSORBER

EXCITED STATE SATURABLE ABSORBER USED WITH 1.06 MICRON NEODYMIUM GLASS LASER RDC-TR-65-369 N66-15701

### ABSORPTION

PUMP TRANSFORMER LASERS - CONVERSION TO SINGLE PLANE-WAVEFRONT BY ABSORPTION AND RE-EMISSION OF MOLECULAR GAS MEDIUM GPL-A-31-1 N65-35530

LASER THEORY WITH CLASSICAL AND QUANTUM MECHANICAL APPROACH TO ABSORPTION AND EMISSION R-1743 N66-20857

### ABSORPTION BAND

SECOND HARMONIC LIGHT GENERATION IN CADMIUM SULFIDE CRYSTAL NEAR ABSORPTION BAND A65-21056

SECOND HARMONIC LIGHT GENERATION IN CADMIUM SULFIDE CRYSTAL NEAR ABSORPTION BAND A65-31220

### ABSORPTION COEFFICIENT

LASER EMISSION USED FOR HEATING PLASMA WITH INITIAL DENSITY NEAR ZERO A65-15535

REABSORPTION AS DOMINANT LOSS MECHANISM FOR BOTH INCOHERENT AND COHERENT RADIATION IN GALLIUM ARSENIDE LUMINESCENT DIODE A65-30347

ABSORPTION COEFFICIENT OF RUBY LASER RADIATION IN FULLY IONIZED LIGHT ELEMENTS IPP-6/27 N65-30178

### ABSORPTION CROSS SECTION

ABSORPTION OF 3.39 MICRON HELIUM-NEON LASER EMISSION BY METHANE IN ATMOSPHERE A65-16362

### ABSORPTION SPECTRUM

GAS LASER MOLECULAR ABSORPTION DISCRIMINATION OF CLOSE FREQUENCIES A65-15998

EMISSION AND ABSORPTION PROFILES FOR RUBY R SUB 1

LINES SHOW ABSENCE OF SIGNIFICANT STOKES SHIFT A65-17664

COLLISION AND POWER BROADENING EFFECTS IN TUNED-LASER ABSORPTION SPECTROSCOPY, USING TIME DEPENDENT PERTURBATION THEORY A65-20065

SPECTROSCOPIC DATA ON ABSORPTION, SPONTANEOUS FLUORESCENCE AND STIMULATED EMISSION IN ACTINIDES, TRANSITION METAL AND SEMICONDUCTOR LASER MATERIAL A65-21168

LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM ION IN VARIOUS CONCENTRATIONS A65-24881

LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM ION IN VARIOUS CONCENTRATIONS A65-36358

HIGH INTENSITY ULTRAVIOLET RADIATION SOURCE TO PUMP PHOSPHORS AND LASER MATERIALS WITH ABSORPTION BANDS IN PHOSPHOR EMISSION SPECTRUM DDRF-173 N65-14365

MATERIAL VAPORIZATION BY Q-SPOILED LASER PULSES FOR SPECTROSCOPIC ANALYSIS OF VAPOR OPTICAL EMISSION AND ABSORPTION PROPERTIES AFCRL-64-871 N65-22274

OPTICAL DOUBLE RESONANCE IN RUBY, DISCUSSING ABSORPTION TRANSITIONS FROM LOWEST EXCITED STATE OF CHROMIUM ION EFFECTED BY LASER PUMPING A66-20856

HE- NE LASER IR RADIATION EMISSION ATTENUATED BY ATMOSPHERIC METHANE A66-23090

LOWER ATMOSPHERE ABSORPTION SPECTRUM STRUCTURE FROM 8512 TO 11600 A - NEODYMIUM LASER SPECTRUM NRL-6352 N66-17604

ANGULAR DEPENDENCE OBSERVATIONS, ABSORPTION MEASUREMENTS, AND HIGH INTENSITY GAS LASER CONSTRUCTION IN STIMULATED RAMAN EMISSION AND ABSORPTION SPECTROSCOPY STUDY AD-626747 N66-23584

### ABSTRACT

SOLID STATE DEVICES, LASERS, AND MATERIALS SCIENCE ABSTRACTS - ANNOTATED BIBLIOGRAPHY ESD-TDR-65-318 N66-16745

### ACETONE

CHELATE LASER SYSTEMS - EUROPIUM BENZOYLACETONATE TR-64-052.7 N65-14405

### ACOUSTIC EXCITATION

LASER PULSE-SHAPING AND MODE-LOCKING WITH TRAVELING AND STATIONARY ACOUSTIC WAVES IN ARGON LASER A65-31763

PARAMETRIC EXCITATION OF ACOUSTIC WAVES IN SIMULATED BRILLOUIN SCATTERING REPT.-1935-5 N65-29906

### ACOUSTIC RADIATION

LOCKING OF MODES IN HE- NE LASER AT 6328 ANGSTROMS, USING EXTERNAL DOPPLER CELL A65-16668

### ACOUSTIC SCATTERING

COHERENT LIGHT DIFFRACTION BY MICROWAVE SOUND IN TRANSPARENT CRYSTALS A65-29265



# ACOUSTIC VELOCITY

# SUBJECT INDEX

FORWARD TRAVELING COHERENT ACOUSTIC WAVE AND  
BACKWARD TRAVELING ELECTROMAGNETIC WAVE PRODUCED  
IN STIMULATED BRILLOUIN SCATTERING OF INTENSE  
LASER BEAM A65-32745

EFFICIENT DIFFRACTION OF INCIDENT LASER BEAM AT  
BRAGG ANGLE INCIDENCE INTO FIRST-ORDER MODE,  
USING TRAVELING ULTRASONIC WAVES IN WATER A65-33057

**ACOUSTIC VELOCITY**  
BRILLOUIN SCATTERING IN LIQUIDS EXCITED BY HE- NE  
MASER AND OBSERVED BY FABRY- PEROT  
INTERFEROMETER, NOTING ACOUSTIC WAVE VELOCITY AND  
LINE BROADENING A65-15699

**ACOUSTIC VIBRATION**  
MASERS AND LASERS, DISCUSSING COHERENT RADIATION  
BY ATOMS AND MOLECULES AND QUANTUM ELECTRONICS  
TECHNIQUES OF GENERATING ACOUSTIC OR  
ELECTROMAGNETIC SPECTRUM A65-31383

EVAPORATED CADMIUM SULFIDE THIN FILMS PROCESSED TO  
ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING  
LASER-INDUCED ELASTIC VIBRATION A65-31942

**ACOUSTICS**  
MICROWAVE PROBLEMS IN ACOUSTIC WAVE INTERACTIONS,  
TRANSVERSE WAVE ELECTRON BEAM, OPTICAL  
SPECTROSCOPY OF LASER MATERIALS, AND NONLINEAR  
QUANTUM STUDIES ML-1243 N65-15605

MICROWAVE RESEARCH ON ACOUSTIC WAVE AMPLIFICATIONS  
AND GEOMETRICAL OPTICS, OPTICAL MASERS,  
ELECTRON-PHONON INTERACTIONS, AND RAMAN  
SCATTERING FROM BIREFRINGENT CRYSTALS ML-1277 N65-20038

SOLID STATE LASERS, ACOUSTICS, AND REGENERATION OF  
MUSCLE TISSUE - TRANSLATIONS OF CHINESE  
PEOPLES' REPUBLIC ARTICLES ON SCIENCE AND  
TECHNOLOGY JPRS-31817 N65-36115

PHONON-PHOTON INTERACTIONS IN OPTICAL SOURCES -  
THEORETICAL DESCRIPTION OF BRAGG AND  
RAMAN-NATH SCATTERING CAUSED BY PROPAGATION OF  
PLANE ACOUSTIC WAVE THROUGH LASER BEAM PATH  
AFOSR-65-2647 N66-22449

**ADENOSINE DIPHOSPHATE**  
PARAMETRIC AMPLIFICATION IN ADENOSINE DIPHOSPHATE  
USING SECONDARY HARMONIC PRODUCED BY RUBY LASER  
RADCC-TDR-64-484 N65-18629

**AERODYNAMICS**  
AERODYNAMIC AND HEAT TRANSFER MEASUREMENTS USING  
INTERFEROMETER WITH CONTINUOUS WAVE LASER AS  
SOURCE A66-10849

**AERONAUTICAL ENGINEERING**  
HE- NE GAS LASER APPLICATION TO SCHLIEREN  
PHOTOGRAPHY AND MACH- ZEHNDER INTERFEROMETRY IN  
AERODYNAMIC TESTING A65-22501

**AEROSOL**  
RUBY LASER IN OPTICAL RADAR PROBE SYSTEM FOR  
BALLOON SOUNDING OF STRATOSPHERIC AEROSOL N65-30205

**AIR BREATHING ENGINE**  
LASER RESEARCH IN U.S.S.R., COMBUSTION  
INSTABILITY IN LIQUID ROCKET AND AIR BREATHING  
PROPULSION, GAS DYNAMICS AND PROPERTIES AT HIGH  
TEMPERATURE, AND MORPHOLOGICAL FORMS IN POLYMERS  
AD-460286 N65-23836

**AIR NAVIGATION**  
OPTICAL DIFFRACTION VELOCIMETER LASER NAVIGATION  
SYSTEM A65-29275

**AIRBORNE EQUIPMENT**  
AIRBORNE LASER-RADAR LIGHT DETECTION AND RANGING  
/ LIDAR/ SYSTEMS APPLIED TO DETECTION OF CLEAR AIR  
TURBULENCE / CAT/ A66-15297

**ALFVEN WAVE**  
PREIONIZATION AND SHOCK WAVE IONIZATION, ALFVEN  
WAVES, LASERS, AND INTERFEROMETER DEVELOPMENT  
NP-15355 N66-13913

**ALKALI HALIDE**  
DECAY OF LASER-INDUCED EXCITATIONS OF F CENTERS  
IN ALKALI HALIDES MSC-387 N65-34867

EXCITED STATE SPECTROSCOPY USING RUBY LASER AND  
LOCALIZED EXCITONS IN ALKALI HALIDES AD-619198 N65-35423

**ALKALI METAL**  
PREPARATION OF SINGLE CRYSTALS OF DOUBLE  
MOLYBDATES OF NA AND LA /OR OTHER RARE EARTH  
ELEMENTS/ DOPED WITH ND, TB OR PR FOR LASER  
APPLICATION A66-13478

**ALTIMETER**  
OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER  
AS AIRCRAFT ALTIMETER TO ELIMINATE SPURIOUS ECHOES  
A65-32588

OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER  
AS TRANSMITTER AND SILICON P-I-N PHOTODIODE AS  
DETECTOR USED AS AIRCRAFT ALTIMETER N66-11665

**ALTITUDE**  
DOPPLER OPTICAL NAVIGATOR TO MEASURE  
INSTANTANEOUS GROUND SPEED WITH 0.1 FT/SEC  
ACCURACY FOR ALTITUDES OF 250 TO 5000 FEET -  
CONTINUOUS WAVE LASER AS TRANSMITTER  
TRG-019-1-2 N65-28160

**ALUMINUM**  
ALUMINUM COLD CATHODES WITH SINGLE MODE  
6328 ANGSTROM HELIUM-NEON GAS LASER LIFETIMES  
EXCEEDING 3000 HOURS A66-10855

**ALUMINUM COMPOUND**  
ALUMINUM NITRATE POWDER MASER DOPED WITH FERRIC  
IONS OPERATION IN X-BAND WITHOUT EXTERNAL DC  
MAGNETIC FIELD A66-11374

**ALUMINUM NITRIDE**  
FOREIGN SCIENCE BULLETIN - GIANT RADIO TELESCOPE  
RAMAN SCATTERING LASERS - FORECASTING SOLAR  
FLARES - MAN-IN-SPACE - EPITAXIAL GROWTH OF  
ALUMINUM NITRIDE THIN FILMS - TECHNOLOGY N65-30979

GIANT RADIO TELESCOPE TO DETECT EXTRATERRESTRIAL  
RADIATION, RAMAN SCATTERING LASERS, FORECASTING  
SOLAR FLARES FOR MANNED SPACE FLIGHT, VOSKHOD  
II LIFE SUPPORT, AND ALUMINUM NITRIDE FILMS  
N65-32675

**ALUMINUM OXIDE**  
ELECTRON BEAM AND HOLLOW CATHODE FLOAT-ZONE  
PROCESSES ANALYSIS FOR APPLICATION TO GROWTH OF  
LASER RUBY CRYSTALS AFCRL-65-908 N66-21169

**AMMONIA**  
AMMONIA BEAM MASERS WITH ASSOCIATED FREQUENCY  
TRANSLATING CIRCUITRY NASA-CR-55839 N65-13558

LASER OSCILLATIONS AT WAVELENGTHS BETWEEN 21 AND  
32 MICRONS FROM PULSED DISCHARGE THROUGH AMMONIA  
N65-20173

CAVITY TUNING OF AMMONIA MASERS BY PRESSURE AND  
ZEEMAN EFFECT MODULATION N65-26684

ZEEMAN EFFECT MODULATION OF AMMONIA MASER FOR  
FREQUENCY STANDARD N65-26685

MASER DEVELOPMENT FROM INVERSIONAL TRANSITIONS IN  
HEAVY AMMONIA BEAM FTD-MT-64-330 N65-36869

AMMONIA MASER - AMMONIA MOLECULAR GENERATOR  
FTD-TT-65-803/16264 N66-19855

- AMMONIUM COMPOUND**  
SECOND HARMONIC GENERATION AND MEASUREMENT OF  
NONLINEAR POLARIZATION CONSTANT IN ADP, USING  
FOCUSED LASER BEAM A65-16672
- AMMONIUM PHOSPHATE**  
CONTINUOUS WAVE MEASUREMENT OF OPTICAL  
NONLINEARITY OF AMMONIUM DIHYDROGEN PHOSPHATE,  
USING HELIUM-NEON LASER A66-23716
- AMPLIFICATION FACTOR**  
NOISE OUTPUT AND NOISE FACTOR OF OVERLOADED MASER  
AMPLIFIERS STUDIED AS FUNCTION OF SMALL-SIGNAL  
GAIN VS ACTUAL GAIN A65-31032
- LINEAR COEFFICIENT OF AMPLIFICATION OF CARBON  
DIOXIDE SUBJECTED TO HF EXCITATION FIELD FOR  
LASER EMISSION A66-12003
- SINGLE PULSE OPERATION OF LASERS, NOTING ENERGY  
STORAGE AND AMPLIFICATION EFFECT FOR FOUR- AND  
THREE-LEVEL ACTIVE MEDIUM A66-23667
- AMPLIFIER**  
GAIN COEFFICIENTS AND MEASUREMENTS IN LASER  
AMPLIFIER, AND SOLID STATE LASER MATERIALS  
QR-6 N65-14465
- FEASIBILITY OF SEMICONDUCTOR LASER AMPLIFIER  
RADC-TDR-64-384 N65-15881
- GAS LASER, EXTERNAL SHUTTER TRIGGER CONTROL,  
MEDIUM POWER LASER, Q-SWITCHING, AND AMPLIFIER  
FOR GEODETIC AND LUNAR SURVEYING  
AFCLRL-65-196 N65-27084
- QUANTUM STATISTICAL PROCEDURE FOR STUDYING  
INTERACTING RADIATION FIELD APPLIED TO MODEL  
LASER OPERATING AS LINEAR AMPLIFIER  
RM-4516-PR N65-27655
- REGENERATIVE RUBY LASER AMPLIFIERS AT LIQUID  
NITROGEN TEMPERATURES  
ECOM-2575 N65-35642
- N EC MASER AMPLIFIER FOR RADIO ASTRONOMICAL  
OBSERVATION OF CYGNUS A, TAURUS A AND ORION  
AND OMEGA NEBULAS A66-15365
- GROWTH OF WAVES IN PULSED LASER AMPLIFIER  
CALCULATED USING QUASI ONE-DIMENSIONAL MODEL -  
AMPLIFICATION OF EXTERNALLY IMPRESSED AND  
SPONTANEOUSLY EMITTED WAVES  
AVCO-EVERETT RES. REPT.-233 N66-10972
- SOLID STATE LASER AMPLIFIER STRUCTURES  
QPR-8 N66-12048
- HIGH POWER LASER AMPLIFIER FOR OPTICAL RADAR  
TRANSMITTER - SPACE SURVEILLANCE SYSTEM  
EOS-5550-Q-1 N66-12355
- AMPLIFIER DESIGN**  
MULTIPLE REFLECTION THEORY APPLIED TO REGENERATIVE  
LASER AMPLIFIER DESIGN  
ECOM-2531 N65-19166
- SUPERCONDUCTING MAGNET FOR VARIABLE BANDWIDTH  
TRAVELING WAVE MASERS, NOTING AMPLIFIER BANDWIDTH  
INCREASE VIA GAIN REDUCTION A66-21417
- AMPLITUDE MODULATION**  
SELF-PULSED MODULATION MODE STABILIZATION OF TWO-  
LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK A65-14144
- SELF-PULSED MODULATION MODE STABILIZATION OF TWO-  
LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK A65-24019
- CAVITY TUNING OF AMMONIA MASERS BY PRESSURE AND  
ZEEMAN EFFECT MODULATION N65-26684
- HELIUM-NEON GAS LASERS, DISCUSSING AMPLITUDE  
VARIATION SUPPRESSION TECHNIQUE A66-16670
- ANALOG COMPUTER**  
OPTICAL ANALOG COMPUTER TRANSPOSING VARIABLE  
INPUTS INTO SPATIAL DIMENSIONS, USING LASER AS  
LIGHT SOURCE FOR ANTENNA MODELING AND SPECTRUM  
ANALYSIS A65-33770
- ANGULAR DISTRIBUTION**  
MEASUREMENT OF RADIATION PATTERN OF RUBY LASER  
EMISSION FOR VARIOUS RESONATORS AND OPERATING  
REGIMES, NOTING LASER EFFECT ON ANGULAR HALF-WIDTH  
VALUES A66-22028
- ANIMAL STUDY**  
CHEMICAL PUMPING OF LASERS - EYE DAMAGE IN  
MONKEYS FROM LASER IRRADIATION  
U-3259 N66-13799
- ANISOTROPIC MATERIAL**  
TWO POLARIZATION EIGENSTATES OCCURRING  
REPETITIVELY IN MULTIPLE PASS INTERFEROMETER  
CONTAINING ANISOTROPIC ELEMENTS, WITH PLANAR LASER  
EXAMPLE A65-21662
- ANNEALING**  
GROWTH AND ANNEALING OF OPTICAL MASER CRYSTALS AND  
SPECTROSCOPIC EVALUATION OF NEODYMIUM-DOPED  
GLASSES  
PE-TR-8110 N66-17007
- ANTENNA ARRAY**  
LOW FREQUENCY MAGNETIC FIELD SENSOR - PROTON  
MASER ANTENNA DESIGN CONSTRUCTION AND  
PERFORMANCE  
RADC-TR-64-567 N65-32211
- ANTIRADIATION DRUG**  
RADIATION PROTECTIVE DRUGS, XENON AND HELIUM-  
XENON LASERS, HELIUM-NEON LASER WITH SILVER AND  
DIELECTRIC COATINGS, AND TRANSISTOR CIRCUITS  
JPRS-29200 N65-20134
- ARGON**  
I R LASER ACTION IN ARGON II BETWEEN 1 AND 2  
MICRONS AND IN 6000 TO 7000 ANGSTROM RANGE  
A65-17207
- TRANSITION PROBABILITIES FOR AR II LASER LINES  
COMPARED WITH PREVIOUS THEORETICAL AND  
EXPERIMENTAL DATA A65-29799
- BREAKDOWN OF ARGON BY NEODYMIUM AND RUBY LASER  
PULSES  
REPT.-1935-1 N65-22072
- HIGH POWER MERCURY LASER OPERATIONS IN KRYPTON AND  
ARGON AS FUNCTION OF MAGNETIC FIELD  
QPR-2 N65-22323
- FLUORESCENT ORGANIC LASER DEVELOPMENT - THETA  
PINCH ARGON LAMP MEASUREMENTS  
QR-7 N65-25966
- RAYLEIGH SCATTERING USING LASER LIGHT FOR  
DETERMINATION OF SCATTERING DENSITY OF ARGON,  
OXYGEN, AND NITROGEN  
R-135 N65-26127
- IONIZATION PHENOMENA IN ARGON DUE TO LASER  
RADIATION BY MEASURING ELECTRON DENSITY AND ENERGY  
AS TIME FUNCTION AFTER LASER PULSE INITIATION AT  
DIFFERENT GAS PRESSURES AND PREIONIZED CONDITIONS  
AIAA PAPER 66-176 A66-21690
- ARC-TUBE CONSTRUCTED FOR COOLING ARGON ION  
LASER - DISCHARGE TUBE  
GE/EE/65-1 N66-14188
- ARGON PLASMA**  
OUTPUT SPECTRA OF ARGON ION LASER IN RING  
RESONATOR AND TWO MIRROR RESONATORS  
A66-14904
- LASER INDUCED GAS BREAKDOWN AT HIGH PRESSURES,  
NOTING EFFECT OF PLASMA DENSITY ON INDEX OF  
REFRACTION VIA OPTICAL FREQUENCY RESONANCE  
MEASUREMENT A66-21564
- AROMATIC COMPOUND**  
PRODUCTION OF STIMULATED EMISSION IN BLUE-GREEN  
REGION IN ORGANIC COPANT AND HOST SYSTEM -  
AROMATIC ORGANIC LASER DEVELOPMENT

## ARSENIC

AD-613295 N65-25734  
 SELECTED FOREIGN SCIENTIFIC AND TECHNICAL  
 LITERATURE ON POTENTIAL THEORY, SEMICONDUCTOR  
 LASERS, COMPOSITE PROPELLANTS, AROMATIC,  
 POLYESTERS, AND TECTONICS N66-21862

## ARSENIC

HIGH POWER GALLIUM-ARSENIC INJECTION LASER DIODES  
 AD-621649 N66-13744

## ASTRONOMY

INVESTIGATIONS IN ASTRONOMY, SOLID STATE PHYSICS,  
 OPTICAL MASERS, ATOMIC PHYSICS, AND RADIOACTIVE  
 ATOMS FOR ELECTROMAGNETIC APPLICATIONS N66-17320  
 NASA-CR-70391

ELECTRO-OPTICS CONTRIBUTIONS TO OPTICAL ASTRONOMY,  
 IMAGE TRANSDUCERS, AND LASER RESEARCH AND EFFECT  
 ON CIVILIAN TECHNOLOGY N66-17721

## ASTROPHYSICS

LABORATORY RESEARCH ON LASER EXCITATION IN SOLIDS,  
 IONIZING RADIATION TRANSMISSION AND PLASMA JETS  
 RELATED TO ASTROPHYSICS A65-14678

## ATMOSPHERIC ABSORPTION

ABSORPTION OF 3.39 MICRON HELIUM-NEON LASER  
 EMISSION BY METHANE IN ATMOSPHERE A65-16362

INTENSE LASER RADIATION PROPAGATION - LASER  
 INDUCED GAS BREAKDOWN, PARAMETRIC INTERACTION,  
 COHERENCE, ATMOSPHERIC ABSORPTION, OPTICAL  
 SOURCE AND INSTRUMENTATION N65-25191  
 AFAL-TR-65-83

## ATMOSPHERIC ATTENUATION

LOW NOISE KA-BAND TRAVELING WAVE MASER AMPLIFIER  
 FOR WINDOW AT 8 MM WHERE ATMOSPHERIC ATTENUATION  
 IS LOW A65-16565

HE- NE LASER IR RADIATION EMISSION ATTENUATED BY  
 ATMOSPHERIC METHANE A66-23090

## ATMOSPHERIC COMPOSITION

OPTICAL RADAR OBSERVATION OF UPPER ATMOSPHERIC  
 CONSTITUENTS BY LASER BEAMS, EXAMINING NEW METHODS  
 BY RESONANCE SCATTERING OF VARIOUS WAVELENGTHS  
 A65-14683

## ATMOSPHERIC CONDITION EFFECT

ATMOSPHERIC EFFECTS ON LASER ENERGY PROPAGATION -  
 LITERATURE SURVEY N65-23622  
 RE-TR-65-3

COHERENT LIGHT COMMUNICATION SYSTEM FOR ATMOSPHERE  
 CONDITION EFFECTS ON FREQUENCY MODULATED LASER  
 BEAM N66-21774  
 FR-66-14-37

## ATMOSPHERIC CONDUCTIVITY

MEASUREMENTS AND LIMITATIONS OF ATMOSPHERIC  
 EFFECTS ON LASER PROPAGATION FOR SPACE  
 COMMUNICATION N65-35846  
 NASA-CR-67382

## ATMOSPHERIC DENSITY

LOWER ATMOSPHERIC DENSITY MEASUREMENTS THROUGH  
 LIGHT SCATTERING FROM Q-SPOILED RUBY LASER BEAM,  
 USING OPTICAL RADAR DETECTOR A66-20398

## ATMOSPHERIC SCATTERING

FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS  
 SYSTEMS, PRIMARILY LIGHT ABSORPTION AND  
 ATMOSPHERIC SCATTERING A65-15349

LASER BEAM BEYOND-HORIZON COMMUNICATION BY MEANS  
 OF CLOUD AND HAZE SCATTERING A65-19596

FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS  
 SYSTEMS, PRIMARILY LIGHT ABSORPTION AND  
 ATMOSPHERIC SCATTERING A65-32353

IMAGE FORMING IN ATMOSPHERIC SCATTERING MEDIUM  
 WITH 60 NANOSECOND ILLUMINATING PULSE FROM  
 Q-SWITCHED RUBY LASER N65-25580  
 AFAL-TR-64-278

## SUBJECT INDEX

MEASUREMENT OF LASER BEAM LIGHT SCATTERED BY  
 ATMOSPHERE N65-36393  
 NASA-CR-67498

UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE  
 RUBY LASER TECHNIQUES, PRESENTING HEIGHT  
 DISTRIBUTION CURVES OF SCATTERED LIGHT A66-13376

RUBY LASER OPTICAL RADAR DETECTION OF UPPER  
 ATMOSPHERIC BACKSCATTERING A66-24395

## ATMOSPHERIC TURBULENCE

STATISTICAL DISTRIBUTION OF ARRIVAL ANGLE, SPOT  
 LOCATION, AMPLITUDE, ETC, OF LASER BEAM TRAVERSING  
 TURBULENT ATMOSPHERE A65-24931

DETECTOR AND SOURCE APERTURE DIMENSIONAL CRITERIA  
 FOR MAINTAINING LONG RANGE LASER BEAM COHERENCE IN  
 TURBULENT AIR A65-28016

ATMOSPHERIC TURBULENCE EFFECT ON OPERATION OF  
 DUAL-POLARIZATION FM LASER COMMUNICATION SYSTEM  
 A65-33377

LIFE SUPPORT SYSTEM, FLUID AMPLIFICATION,  
 SPALLING, COMMUNICATIONS SATELLITE, MICROWAVE  
 APPARATUS, HIGH STRENGTH STEEL, TRACERS, LASERS,  
 ATMOSPHERIC TURBULENCE, AND RESONANCE N65-22732  
 AD-611432

AIRBORNE LASER-RADAR LIGHT DETECTION AND RANGING  
 / LIDAR/ SYSTEMS APPLIED TO DETECTION OF CLEAR AIR  
 TURBULENCE / CAT/ A66-15297

ATMOSPHERIC TURBULENCE, POWER FLUCTUATION AND  
 RADAR DETECTION IN LASER SYSTEMS DESIGN A66-17294

## ATMOSPHERICS

PROPAGATION OF ATMOSPHERICS, RADIATIVE  
 RECOMBINATION IN LASERS, RADIATION BELT  
 SURROUNDING EARTH, EQUATION FOR LAMINAR BOUNDARY  
 LAYER PROBLEMS, AND RARE EARTH SILICIDES N66-12644

## ATOM

SPONTANEOUS EMISSION FROM ATOM INTERACTING WITH  
 COHERENT LIGHT WAVE N66-12043  
 AFOSR-65-1000

## ATOMIC BEAM

HYDROGEN MASER AND CESIUM BEAM TUBE FREQUENCY  
 STANDARDS COMPARED A65-16680

FREQUENCY STANDARDS OF HYDROGEN MASER AND SWISS  
 CESIUM ATOMIC BEAM TUBE COMPARED A65-16681

SEPARATION AND FOCUSING OF ATOMIC BEAMS FOR ATOMIC  
 HYDROGEN MASERS N65-26679

ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION  
 INVERSION IN LEVELS OF OPTICAL TRANSITION A66-10448

ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION  
 INVERSION IN LEVELS OF OPTICAL TRANSITION A66-13311

## ATOMIC CLOCK

STATISTICAL ANALYSIS OF NOISE QUALITY OF ATOMIC  
 FREQUENCY STANDARDS INCLUDING MASERS A66-24130

## ATOMIC COLLISION

LASER OPERATION MODES ARISING FROM METASTABLE NEON  
 ATOM ANNIHILATION BY HYDROGEN AND OXYGEN MOLECULES  
 A65-18557

LASER OPERATION MODES ARISING FROM METASTABLE  
 NEON ATOM ANNIHILATION BY HYDROGEN AND OXYGEN  
 MOLECULES A65-27150

## ATOMIC EXCITATION

CHEMICAL PROCESSES PRODUCING SPECTROSCOPICALLY  
 OBSERVABLE POPULATION INVERSIONS IN ATOMIC OR  
 MOLECULAR LASERS A65-20066

# SUBJECT INDEX

# BEAM-PLASMA AMPLIFIER

- LASER OPERATION PRINCIPLES AND OSCILLATING ELEMENT OF LASER RESONATOR A65-31880
- GAS LASER EMISSION SOLUTION BY DETERMINING EMISSION FIELD DENSITY DEPENDENCE ON RESONATOR PARAMETERS, RELAXATION CHARACTERISTICS AND ATOM EXCITATION IN GAS DISCHARGE PLASMA A65-35868
- F M LASER OSCILLATION THEORY DISCUSSING EFFECT OF ARBITRARY ATOMIC LINE SHAPE, SATURATION, MODE PULLING, POWER OUTPUT, SIDEBAND AMPLITUDE, DISTORTION, ETC A66-13954
- SOLID STATE LASER SYSTEM, DESCRIBING QUANTUM MECHANICAL TREATMENT OF SELF-SUSTAINED OSCILLATION FOR ONE MODE A66-17817
- FREQUENCY STABILIZATION OF GAS LASERS, USING ATOMIC RESONANCE AND INTERFEROMETERS A66-18357
- GAS LASER EMISSION SOLUTION BY DETERMINING EMISSION FIELD DENSITY DEPENDENCE ON RESONATOR PARAMETERS, RELAXATION CHARACTERISTICS AND ATOM EXCITATION IN GAS DISCHARGE PLASMA A66-19271
- DEGREE OF EXCITATION OF METASTABLE STATE DETERMINED, USING LUMINESCENCE SATURATION PHENOMENON, CALCULATING POPULATION OF WORKING LEVEL OF LASER SUBSTANCE A66-22027
- QUANTUM MECHANICAL NONLINEAR THEORY OF INTENSITY AND PHASE FLUCTUATIONS OF HOMOGENEOUSLY BROADENED LASER NOISE A66-22466
- PULSE EXCITATION OF VOLUME OF GAS TO COHERENTLY RADIATING STATE APPLIED TO BEAM MASER SPECTROMETER A66-23731
- ATTITUDE INDICATOR  
ROCKET MISSILE ATTITUDE SENSING DURING EARLY LAUNCH PHASE USING POLARIZED LASER BEAMS TRANSMITTED FROM GROUND STATION A65-23619
- AUREOLE  
FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK SHOCK WAVE IN LASER BEAM A66-10263
- FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK SHOCK WAVE IN LASER BEAM A66-13308
- AUTOMATIC FREQUENCY CONTROL  
AUTOMATIC FREQUENCY CONTROL OF LASER LOCAL OSCILLATOR FOR HETERODYNE DETECTION OF LASER SIGNAL AND USE OF 2.5 GC FREQUENCY OFFSET TO PERMIT RETRIEVAL OF MICROWAVE DATA A66-14908
- AVALANCHE  
GAS BREAKDOWN BY LASER CAN BE ACCOUNTED FOR BY BOTH MICROWAVE BREAKDOWN THEORY AND INVERSE BREMSSTRAHLUNG A66-17040
- AVALANCHE RECTIFIER  
MICROWAVE AMPLIFICATION ACHIEVED IN SILICON DIODE EXHIBITING MICROPLASMA-FREE AVALANCHE MULTIPLICATION A65-19227
- ## B
- BACKGROUND EFFECT  
BACKGROUND GAS PRESSURE EFFECT ON LASER INDUCED ELECTRON EMISSION FROM ZINC AND TANTALUM SURFACES A65-15838
- BACKSCATTER  
REDUCTION OF LOCKING FREQUENCY OF RING LASER BY MAKING TWO BEAMS ORTHOGONAL A65-19601
- MEASUREMENT OF LASER BEAM LIGHT SCATTERED BY ATMOSPHERE  
NASA-CR-67498 N65-36393
- CROSS SECTION MEASUREMENT FOR ELECTROMAGNETIC BACKSCATTERING OF LASER BEAMS FROM ROUGH ALUMINUM AND MAGNESIUM OXIDE SURFACES A66-18930
- RUBY LASER OPTICAL RADAR DETECTION OF UPPER ATMOSPHERIC BACKSCATTERING A66-24395
- CONCEPTUAL MODEL OF BACKSCATTERED FIELD OF LASERS AND USE FOR ROTATION DETECTION  
GE/EE/65-13 N66-16473
- EARTH ATMOSPHERE PROPERTIES INVESTIGATION BASED ON LASER BEAM BACKSCATTERING MEASUREMENTS  
NASA-CR-70177 N66-16967
- BACKWARD WAVE  
FORWARD TRAVELING COHERENT ACOUSTIC WAVE AND BACKWARD TRAVELING ELECTROMAGNETIC WAVE PRODUCED IN STIMULATED BRILLOUIN SCATTERING OF INTENSE LASER BEAM A65-32745
- BALLOON  
BALLOON-BORNE XENON LIGHT OPTICAL BEACON FOR LASER AND OPTICAL TRACKING, AND MISSILE-BORNE XENON OPTICAL BEACON FOR OPTICAL TRACKING  
B-3068 N65-31897
- BALLOON SOUNDING  
RUBY LASER IN OPTICAL RADAR PROBE SYSTEM FOR BALLOON SOUNDING OF STRATOSPHERIC AEROSOL N65-30205
- BAND PASS FILTER  
TWO-FREQUENCY VOLUME RESONATOR WITH INDEPENDENT TUNING WITHIN WIDE FREQUENCY BAND A66-18918
- BANDWIDTH  
WIDTH OF LINES EMITTED BY LASER MODELS  
FTD-TT-64-841 N65-14217
- GAIN AND BANDWIDTH NARROWING IN REGENERATIVE HELIUM-XENON LASER AMPLIFIER A66-12308
- BARIUM TITANATE  
OPTICAL PHASE MODULATOR USING FERROELECTRIC BARIUM TITANATE CRYSTAL PLATE A66-10240
- BARIUM ZIRCONATE  
CRYSTAL GROWTH, LATTICE CONSTANT, AND DENSITY OF MAGNESIUM POTASSIUM FLUORIDE AND BARIUM ZIRCONATE  
AD-623511 N66-14467
- BEACON  
BALLOON-BORNE XENON LIGHT OPTICAL BEACON FOR LASER AND OPTICAL TRACKING, AND MISSILE-BORNE XENON OPTICAL BEACON FOR OPTICAL TRACKING  
B-3068 N65-31897
- BEACON SATELLITE  
LASER RANGING EXPERIMENTS PERFORMED WITH BEACON EXPLORER B A65-21303
- ACCURATE TRACKING OF BEACON- EXPLORER ORBITING OPTICAL REFLECTORS, USING PULSED RUBY LASER BEAMS A66-19902
- BEAM COLUMN  
METHOD FOR PRODUCING COMPACT BEAM FROM ARRAY OF LASERS N65-20176
- BEAM CURRENT  
TWO TYPES OF NONLINEAR INTERACTION OF INTENSE LASER BEAM WITH DIELECTRIC MEDIUM - NONLINEAR DC POLARIZATION AND SUBHARMONICS GENERATION AT OPTICAL FREQUENCIES  
AD-618473 N65-33899
- COMPARISON OF HYDROGEN MASER AND OF CESIUM BEAM TUBE FREQUENCY STANDARD  
NASA-TN-D-3292 N66-21698
- BEAM-PLASMA AMPLIFIER  
LINEAR BEAM AND MICROWAVE POWER GENERATION - BEAM-CIRCUIT INTERACTION, BASIC CIRCUITS, BEAM-PLASMA AMPLIFIER, AND LASER-STIMULATED THERMIONIC EMISSION  
RADC-TR-65-22 N65-27099

# BEAM SWITCHING

## BEAM SWITCHING

PHOTOGRAPHIC FILM USED FOR QUANTITATIVE MEASUREMENTS OF INTENSITY DISTRIBUTION IN Q-SWITCHED LASER BEAM A66-14920

## BEAM WAVEGUIDE

PIEZOELECTRICALLY POWERED LASER BEAM WAVEGUIDE FOR ELECTRO-OPTICAL ACQUISITION AND TRACKING NASA-CR-68895 N66-17291

## BENZENE

STIMULATED RAMAN EFFECT OF BENZENE USING RUBY LASER, EXAMINING OUTPUT SPECTRUM, THRESHOLD POWER AND EFFICIENCY AT STOKES LINES A65-19598

## BESSEL FUNCTION

HELIUM-NEON GAS DISCHARGE INTENSIFICATION FOR 6328 Å LASER WAVELENGTH, DISCUSSING MEASUREMENT TECHNIQUES, GAIN PARAMETERS AND RESULTS A66-18632

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SOVIET LASER RESEARCH - BIBLIOGRAPHY ATD-P-65-23 N65-28795

BIBLIOGRAPHY ON BIOLOGICAL EFFECTS AND HAZARDS OF LASER RADIATION TS-1245/3111 N65-33997

LASER BIBLIOGRAPHY COVERING DEVICES AND RELATED SYSTEMS FOR PERIOD JANUARY- JUNE 1965 A66-11372

BIBLIOGRAPHY OF OPEN LITERATURE ON LASERS, PART V A66-22876

SOLID STATE DEVICES, LASERS, AND MATERIALS SCIENCE ABSTRACTS - ANNOTATED BIBLIOGRAPHY ESD-TDR-65-318 N66-16745

## BIOINSTRUMENTATION

RECORDING SAMPLING SYSTEM FOR MEASURING ENERGY INCIDENT ON BIOLOGICAL SYSTEM EXPOSED TO LASER BEAM A66-17293

## BIOLOGICAL CELL

EFFECT OF RUBY LASER ENERGY ON GAMMA RADIATED HUMAN ADENOCARCINOMA CELLS SAM-TR-65-41 N66-11874

## BIOLOGICAL EFFECT

BIOLOGICAL EFFECTS OF LASER RADIATION AND SAFETY RULES FOR PERSONNEL PROTECTION NAVTRADEVEN-1H-15 N65-14941

RADIOMETER MASERS, MICROWAVE GENERATION, BIOLOGICAL ASPECTS OF MICROWAVES, POLYMERIZATION AND OPTIMAL CONTROL AD-455792 N65-18884

BIOLOGICAL EFFECTS OF LASER RADIATION WITH REFERENCE TO INTACT ANIMALS, PRIMATE EYES AND SKIN AND MALIGNANT TUMORS OF ANIMAL AND HUMAN ORIGIN A66-12994

LASER BEAM USE IN BIOLOGY AND MEDICINE, NOTING INTERACTION OF ELECTROMAGNETIC RADIATION WITH BIOLOGICAL SYSTEMS, HAZARDS, DIAGNOSTICS, THERAPEUTICS, ETC A66-14455

## BIREFRINGENCE

HIGH POWER LASER BEAM COLLINEARIZATION USING BIREFRINGENCE OF UNIAXIAL CALCITE CRYSTAL PRISM A65-25828

MICROWAVE RESEARCH ON ACOUSTIC WAVE AMPLIFICATIONS AND GEOMETRICAL OPTICS, OPTICAL MASERS,

# SUBJECT INDEX

ELECTRON-PHONON INTERACTIONS, AND RAMAN SCATTERING FROM BIREFRINGENT CRYSTALS ML-1277 N65-20038

EFFECT OF COMPOSITION ON THERMAL EXPANSION COEFFICIENT, THERMAL COEFFICIENT OF REFRACTIVE INDEX, BIREFRINGENCE, AND STRESS-OPTICAL COEFFICIENTS FOR ATHERMALIZING LASER GLASS TSR-5 N65-25688

## BISMUTH

MICROWAVE PROPERTIES PARTICULARLY LINEWIDTH AND MAGNETIC ANISOTROPY IN CALCIUM-VANADIUM BISMUTH GARNET, NOTING TWM ISOLATOR A65-24964

## BLOOD CIRCULATION

RETINAL VASCULATURE OF RABBIT AND MONKEY AS AFFECTED BY LASER IRRADIATION PROXIMITY OF PIGMENT EPITHELIUM, BLOOD FLOW, AND AMOUNT OF REDUCED HEMOGLOBIN A66-80470

## BOLOMETER

PULSED RUBY LASER OUTPUT MEASUREMENT BY OPTICAL BOLOMETER A65-18017

OUTPUT POWER OF CW LASER MEASURED BY WIRE BOLOMETER IN FORM OF PLANE SINGLE-LAYER SPIRAL AS SENSITIVE ELEMENT A66-20364

## BOLTZMANN DISTRIBUTION

NORMAL BOLTZMANN DISTRIBUTION INVERSION IN MOLECULAR BEAM TO OBTAIN EXCESS UPPER ENERGY LEVEL POPULATION FOR MASER OSCILLATION A65-15801

## BORATE

EFFECT OF LASER OPERATION PARAMETERS USING NEODYMIUM DOPED BORATE GLASS ON THRESHOLD AND OUTPUT ENERGY R-1748 N65-25782

## BRAGG EQUATION

PHONON-PHOTON INTERACTIONS IN OPTICAL SOURCES - THEORETICAL DESCRIPTION OF BRAGG AND RAMAN-NATH SCATTERING CAUSED BY PROPAGATION OF PLANE ACOUSTIC WAVE THROUGH LASER BEAM PATH AFOSR-65-2647 N66-22449

## BREMSSTRAHLUNG

CUT-OFF OF RUBY LASER EMISSION BY PULSED ELECTRON AND BREMSSTRAHLUNG RADIATION, USING ADIABATIC TEMPERATURE A66-12447

GAS BREAKDOWN BY LASER CAN BE ACCOUNTED FOR BY BOTH MICROWAVE BREAKDOWN THEORY AND INVERSE BREMSSTRAHLUNG A66-17040

## BRILLOUIN EFFECT

HYPERSONIC WAVES PRODUCED BY BRILLOUIN EFFECT, USING METHOD OF TWO INTENSE LIGHT BEAMS A65-14874

BRILLOUIN SCATTERING IN LIQUIDS EXCITED BY HE- NE MASER AND OBSERVED BY FABRY-PEROT INTERFEROMETER, NOTING ACOUSTIC WAVE VELOCITY AND LINE BROADENING A65-15699

STIMULATED BRILLOUIN RADIATION IN OFF-AXIS RUBY LASER RESONATOR USING CARBON DISULFIDE CELL, EXAMINING OUTPUT SPECTRUM A65-16811

FORWARD TRAVELING COHERENT ACOUSTIC WAVE AND BACKWARD TRAVELING ELECTROMAGNETIC WAVE PRODUCED IN STIMULATED BRILLOUIN SCATTERING OF INTENSE LASER BEAM A65-32745

OPTICAL MASER APPLIED TO BRILLOUIN SCATTERING SPECTROSCOPY PR-3 N65-13790

OPTICAL MASER APPLIED TO BRILLOUIN SCATTERING SPECTROSCOPY AROD-3922-13 N65-19528

PARAMETRIC EXCITATION OF ACOUSTIC WAVES IN SIMULATED BRILLOUIN SCATTERING REPT.-1935-5 N65-29906

STIMULATED BRILLOUIN SCATTERING OF INTENSE LASER

# SUBJECT INDEX

# CALCIUM FLUORIDE

- LIGHT WITH BUILD-UP OF COHERENT HYPERSONIC WAVES IN LIQUIDS  
NASA-CR-58214 N65-33710
- BRILLOUIN SCATTERING IN LIQUIDS EXAMINING VELOCITY, FREQUENCY AND LIFETIME OF THERMALLY EXCITED HYPERSONIC SOUND WAVES, USING LASER LIGHT SOURCES A66-12422
- STIMULATED BRILLOUIN AND RAMAN SCATTERING IN GASES, DISCUSSING SOUND VELOCITY CALCULATION FROM FREQUENCY SHIFT AND ARGON, HYDROGEN AND NITROGEN A66-13981
- MOLECULAR ANISOTROPY OF PROPAGATION OF INTENSE LIGHT BEAM, NOTING RAMAN AND BRILLOUIN EFFECTS A66-15106
- BRILLOUIN SCATTERING OF LIGHT BY PHONONS AND PHONON MASER IN DERIVATION OF CONSERVATION THEOREMS FROM BASIC EQUATIONS A66-18397
- GAS SPECTROSCOPY OF LASER-INDUCED STIMULATED BRILLOUIN EFFECT IN HIGH PRESSURE OXYGEN A66-23432
- BROADBAND AMPLIFIER**  
SOLID STATE MICROWAVE MASER ACTION AT 77.4 DEGREES K WITH BROADBANDING TECHNIQUE APPLIED TO INCREASE GAIN-BANDWIDTH PRODUCT, EXAMINING RUBY MATERIAL AND HIGH Q MICROWAVE CAVITIES A65-23155
- BROADBAND TRAVELING WAVE MASER TECHNIQUES AND N-TYPE GERMANIUM SEMICONDUCTOR DEVELOPMENT RADC-TR-65-366 N66-15720
- MULTICOIL SUPERCONDUCTING MAGNETS FOR BROADBAND TRAVELING WAVE MASERS NASA-CR-386 N66-18174
- BUBBLE**  
RUBY LASER HIGH SPEED PHOTOGRAPHY OF CAVITATION DAMAGE TO SOLIDS DUE TO HIGH SPEED JETS FROM COLLAPSING BUBBLES E-115.1 N66-21887
- BUBBLE CHAMBER**  
RUBY LASER WITH CONCENTRIC RESONATOR AS ILLUMINATION SOURCE OF BUBBLE CHAMBER A66-11189
- LASER SIMULATED NUCLEATION IN BUBBLE CHAMBER, COMPARING SENSITIVITY WITH RADIOACTIVELY STIMULATED NUCLEATION A66-21583
- RUBY LASER WITH CONCENTRIC RESONATOR AS ILLUMINATION SOURCE OF BUBBLE CHAMBER A66-24010
- C**
- CADMIUM**  
LASER OSCILLATION IN VISIBLE SPECTRA OF SINGLY IONIZED ZINC AND CADMIUM OBTAINED WITH PULSED DISCHARGES IN HEATED VAPORS OF THESE METALS MIXED WITH NOBLE GASES A65-32747
- CADMIUM FLUORIDE**  
LASER REGIME WITH GIANT PULSES GENERATED IN DYSPROSIUM DOPED CADMIUM FLUORIDE UNDER CONTINUOUS PUMPING BY XENON LAMPS, OBTAINING Q FACTOR MODULATION BY ROTATING PRISM A66-19376
- CADMIUM SELENIDE**  
FORCED EMISSION FROM ELECTRON-EXCITED CADMIUM SELENIDE A66-22174
- CADMIUM SULFIDE**  
SECOND HARMONIC LIGHT GENERATION IN CADMIUM SULFIDE CRYSTAL NEAR ABSORPTION BAND A65-21056
- PROCESSING EVAPORATED CADMIUM SULFIDE THIN FILMS TO ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING LASER-INDUCED ELASTIC VIBRATIONS A65-21875
- LASER BEAM DEFLECTION MODULATION OBTAINED BY PASSING CURRENT THROUGH CADMIUM SULFIDE PRISM WITH OHMIC CONTACTS, USED FOR THERMOCOUPLE MEASUREMENTS A65-25890
- SECOND HARMONIC LIGHT GENERATION IN CADMIUM SULFIDE CRYSTAL NEAR ABSORPTION BAND A65-31220
- EVAPORATED CADMIUM SULFIDE THIN FILMS PROCESSED TO ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING LASER-INDUCED ELASTIC VIBRATION A65-31942
- FLUORESCENCE FROM CADMIUM SULFIDE EXCITED BY RUBY LASER COMPARED WITH PHOTOCONDUCTIVITY INDUCED BY ORDINARY GREEN LIGHT TO SUPPORT DOUBLE PHOTON ABSORPTION MECHANISM A65-34665
- CD S SINGLE CRYSTAL OPTICAL GENERATOR DURING EXCITATION BY RUBY LASER, DISCUSSING TWO-PHOTON ABSORPTION COEFFICIENT AT 300 DEGREES K FOR RADIATION FLUX DENSITIES A66-13874
- LASER EMISSION IN PURE CADMIUM SULFIDE CRYSTALS BOMBARDED BY ELECTRON BEAMS A66-18650
- GENERATION IN CADMIUM SULFIDE DURING TWO-PHOTON OPTICAL EXCITATION BY RUBY LASER WITH MODULATED Q-FACTOR A66-19620
- CADMIUM TELLURIDE**  
CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION A66-11188
- CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION A66-24009
- RADIATIVE RECOMBINATION WITH ELECTRON BEAM EXCITED CADMIUM TELLURIDE AND GALLIUM SELENIDE N66-12646
- CALCITE**  
HIGH POWER LASER BEAM COLLINEARIZATION USING BIREFRINGENCE OF UNIAXIAL CALCITE CRYSTAL PRISM A65-25828
- CRYSTALLINE CALCITE USED AS DICHROIC POLARIZER IN IR REGIONS, LASER RADIATION, ZEEMAN EFFECT AND NOISE PROPERTIES MEASUREMENTS, ETC A65-33419
- CALCIUM**  
MICROWAVE PROPERTIES PARTICULARLY LINewidth AND MAGNETIC ANISOTROPY IN CALCIUM-VANADIUM BISMUTH GARNET, NOTING TWM ISOLATOR A65-24964
- CALCIUM COMPOUND**  
CONTINUOUS LASER ACTION IN NEODYMIUM DOPED CALCIUM MOLYBDATE AT ROOM TEMPERATURE A65-21627
- CALCIUM FLUORIDE**  
FABRICATION AND TEST OF CONTINUOUS WAVE LASER ACTION FROM DYSPROSIUM IN CALCIUM FLUORIDE EXCITED BY TUNGSTEN LAMP A65-19184
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM FLUORIDE DOPED WITH SAMARIUM A65-24085
- LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM ION IN VARIOUS CONCENTRATIONS A65-24881
- OXYGEN AS CAUSE OF SCATTERING AND CONVERSION OF IMPURITIES TO HIGHER VALENCE STATE IN CALCIUM FLUORIDE LASER SYSTEM A65-30800
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM FLUORIDE DOPED WITH SAMARIUM A65-34906
- LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM ION IN VARIOUS CONCENTRATIONS A65-36358
- DYSPROSIUM DOPED CALCIUM FLUORIDE DOPED LASER, USING SOLAR RADIATION FOR EXCITATION AND OPERATING AT 77 DEGREES K A65-36361
- RUBY LASER RADIATION EFFECT ON FLUORESCENCE AND

# CALCIUM TUNGSTATE

LASER ACTION IN DYSPROSIUM DOPED CALCIUM FLUORIDE CRYSTALS A66-10718

# CALCIUM TUNGSTATE

QUASI-CONTINUOUS OPERATION OF CALCIUM TUNGSTATE/NEODYMIUM ION MASER USING LONG DURATION PUMPING PULSES A65-16575

NEODYMIUM DOPED CALCIUM TUNGSTATE ROOM TEMPERATURE AMPLIFIER AND C W-LASER OSCILLATOR A65-18873

OSCILLATORY BEHAVIOR OF NEODYMIUM DOPED CALCIUM TUNGSTATE SOLID STATE LASERS WITH CW EMISSION BASED ON RATE EQUATIONS A65-19998

POWER OUTPUT AND THRESHOLD POWER FOR CONTINUOUS WAVE NEODYMIUM-CALCIUM TUNGSTATE LASER IN RANGE OF DRY ICE TO ROOM TEMPERATURE A65-22619

CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH NEODYMIUM IONS A65-31703

SUN-POWERED LASER TRANSMITTER DEVELOPMENT - RUBY, NEODYMIUM-DOPED GLASS, AND NEODYMIUM-DOPED CALCIUM TUNGSTATE LASER MATERIALS IER-1 N65-29901

LASER OSCILLATION IN CALCIUM TUNGSTATE CRYSTALS ACTIVATED WITH TRIVALENT PRASEODYMIUM A66-14898

CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH NEODYMIUM IONS A66-19956

# CALORIMETER

PULSE ENERGY AND POWER OF LASERS UNDER CONTINUOUS OPERATING CONDITIONS MEASURED, USING CALORIMETERS, PHOTOELECTRIC EFFECT OF RADIATION, ETC A66-13205

# CAPACITOR

TEXT ON HIGH SPEED OPTICAL PULSE TECHNOLOGY, LASERS AND MEASURING TECHNIQUES, EMPHASIZING CAPACITOR DISCHARGE APPLICATION A66-22063

# CARBON COMPOUND

DYNAMICS AND CHARACTERISTICS OF SELF-TRAPPING OF INTENSE LIGHT BEAMS NASA-CR-74030 N66-23765

# CARBON DIOXIDE

CARBON MONOXIDE AND DIOXIDE VIBRATIONALLY INDUCED IR EMISSION WITH POSSIBLE APPLICATIONS TO CONTINUOUS LASER EMISSION A65-22463

CONTINUOUS LASER EMISSION DUE TO VIBRATIONAL TRANSITIONS IN CARBON DIOXIDE AND NITROUS OXIDE MIXTURES EXCITED BY HF SOURCE A65-26292

LASER ACTION ON P- AND R-BRANCH TRANSITIONS OF CARBON DIOXIDE VIBRATIONAL SPECTRUM BAND PRODUCED BY PULSED DISCHARGE ADMIXTURE OF VARIOUS GASES A65-33058

LINEAR COEFFICIENT OF AMPLIFICATION OF CARBON DIOXIDE SUBJECTED TO HF EXCITATION FIELD FOR LASER EMISSION A66-12003

C W LASER ACTION IN CARBON DIOXIDE-HELIUM MIXTURES A66-16385

# CARBON DISULFIDE

STIMULATED BRILLOUIN RADIATION IN OFF-AXIS RUBY LASER RESONATOR USING CARBON DISULFIDE CELL, EXAMINING OUTPUT SPECTRUM A65-16811

C W LASER OSCILLATION BETWEEN 11.48 AND 11.55 MICRONS FROM NITROGEN-CARBON DISULFIDE SYSTEM A66-16384

# CARBON MONOXIDE

CARBON MONOXIDE AND DIOXIDE VIBRATIONALLY INDUCED IR EMISSION WITH POSSIBLE APPLICATIONS TO CONTINUOUS LASER EMISSION A65-22463

# SUBJECT INDEX

C W GAS LASER, MEASURING VIBRATIONAL ROTATIONAL TRANSLATION FREQUENCIES OF CARBON MONOXIDE A66-13984

LASER ACTION ON ROTATIONAL TRANSITIONS OF 10-9, 9-8, 8-7, 7-6 AND 6-5 VIBRATIONAL BANDS OF GROUND ELECTRONIC STATE CO A66-18424

# CARBON TETRACHLORIDE

CARBON AND ETHYLENE TETRACHLORIDE ULTRASONIC MODULATORS APPLIED TO IR LASER HETERODYNE EXPERIMENTS ON IN AS PHOTODIODE A66-23353

# CARRIER

EXCITATION OF AXIAL OSCILLATION MODES IN SEMICONDUCTOR LASERS ANALYZED, BASED ON RATE EQUATIONS FOR CHEMICAL POTENTIALS OF CARRIERS AND NUMBER OF PHOTONS A66-24455

# CARRIER FREQUENCY

CARRIER FREQUENCY STABILIZATION OF FM LASER WITH RESPECT TO CENTER OF ATOMIC GAIN PROFILE, USING SMALL DISTORTION PRESENT IN LASER OSCILLATION A66-10966

# CATHODE RAY TUBE

CATHODOLUMINESCENT PHOSPHORS AS LIGHT SOURCE FOR LASERS, REDUCING HEAT LIMITATIONS AND ELIMINATING INTERNAL STRESSES CAUSED BY THERMAL GRADIENTS A65-30436

ELECTRONIC DEVICES - DUPLEXERS, PLASMA AMPLIFIERS, CATHODE RAY TUBES, CAPACITORS, THIN FILM TECHNIQUES, AND OPTICAL MASERS SR-85 N65-33773

# CATION

ORGANIC CATIONS EFFECT ON LASER THRESHOLD OF SOLUTIONS OF TETRAKIS FORM OF EUROPIUM BENZOYLTRIFLUOROACETONATE A66-18418

# CAVITATION

RUBY LASER HIGH SPEED PHOTOGRAPHY OF CAVITATION DAMAGE TO SOLIDS DUE TO HIGH SPEED JETS FROM COLLAPSING BUBBLES E-115.1 N66-21887

# CAVITY

GAIN SATURATION, LIGHT POWER LEVEL, DISCHARGE CURRENT AND METHOD FOR SPECIFYING OUTPUT POWER CHARACTERISTICS OF LASER TUBE A65-15326

REFRACTIVE INDEX VARIATION DURING LASER OPERATION AND CAST-PLASTIC OPTICAL-PUMP CAVITY EQUIPMENT FOR PUMPING AND TEMPERATURE CONTROL DURING EXPERIMENT SATR-1 N65-15753

TIME RESOLVED INTERFEROMETRY, CINEMATOGRAPHY, AND TRAVELING WAVE CAVITY STUDIES ON RUBY LASERS AFCRL-65-467 N66-16656

SPECTRAL LINE WIDTH NARROWING IN TRAVELING WAVE RUBY LASER CAVITY EMISSION N66-16658

# CAVITY RESONANCE

SELF-CONSISTENT FIELD ANALYSIS FOR FIELD DISTRIBUTIONS OF RESONANT MODES IN SPHERICAL MIRROR FABRY-PEROT RESONATOR A65-16566

AUTOMATIC FEEDBACK CONTROL FOR LONG-TERM FREQUENCY STABILIZATION OF HE-NE LASER AT CENTER FREQUENCY OF ATOMIC RESONANCE A65-21620

SOLID STATE MICROWAVE MASER ACTION AT 77.4 DEGREES K WITH BROADBANDING TECHNIQUE APPLIED TO INCREASE GAIN-BANDWIDTH PRODUCT, EXAMINING RUBY MATERIAL AND HIGH Q MICROWAVE CAVITIES A65-23155

LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS A65-24879

LASER OPERATION AS PULSED REGENERATIVE OSCILLATOR ARISING FROM MODE COUPLING DUE TO TIME-VARYING LOSS IN CAVITY OR NONLINEAR CHARACTERISTICS OF INVERTED POPULATION A65-27603

# SUBJECT INDEX

# CHEMICAL REACTION

- BEAT FREQUENCIES AND COHERENCE PROPERTIES IN CIRCULARLY POLARIZED ATOMIC TRANSITIONS OF GASEOUS LASERS WITH AXIAL MAGNETIC FIELDS  
A66-18429
- BEAT FREQUENCY AND ROTATION OF POLARIZATION PLANE IN He-Ne LASER WITH AXIAL MAGNETIC FIELD  
A66-18430
- RESONANT CAVITY, OSCILLATION AND RADIATION OUTPUT OF OPTICAL MASERS  
FTD-TT-64-1231/1626364  
N66-11458
- CAVITY RESONATOR  
STIMULATED COMBINATION LIGHT SCATTERING WITHIN AND OUTSIDE RESONATOR CAVITY BASED ON LASER DEVELOPMENT  
A65-16627
- MODE LOCKING IN HELIUM-NEON LASER BY MEANS OF SYNCHRONOUS INTRACAVITY ACOUSTIC MODULATION IN COUPLED MULTIMODE CONFOCAL INTERFEROMETERS  
A65-24276
- MICROWAVE OR LASER RESONATOR WITH FLAT-ROOF MIRROR HAS VERY SMALL DIFFRACTION LOSSES AND IS INSENSITIVE TO MISALIGNMENT WHEN ROOF ANGLE IS VERY SMALL  
A65-34606
- INTENSITY DISTRIBUTION IN FABRY-PEROT INTERFEROMETER PRODUCING RESONANT WAVES FOR LARGE FRESNEL NUMBER APPLIED IN MODEL FOR FILAMENT-FORM LASER MECHANISM  
A66-13097
- MODE SELECTIVE CHARACTERISTICS OF PLANE-PARALLEL DIELECTRICAL PLATE AS REFLECTOR FOR RUBY LASER RESONATOR  
A66-14330
- QUANTUM MECHANICAL TREATMENT OF MOLECULAR RADIATION BEHAVIOR IN DETUNING CAVITY OF DOUBLE CAVITY MASER  
FTD-TT-65-888/1626364  
N66-19899
- CENTRIFUGE  
RING LASER ANGULAR ROTATION SENSOR DESIGNED FOR CENTRIFUGE OPERATION  
AB-1272-0028-1  
N65-16131
- CESIUM  
COMPACT SOLID STATE CESIUM LASER BEAM FREQUENCY STANDARD FOR PRECISION CLOCKS  
N65-26681
- THEORY AND APPLICATION OF MASERS AND LASERS - CESIUM, HELIUM-NEON, AND RUBY MASER OSCILLATOR SYSTEMS  
N65-31361
- CESIUM DIODE  
COMPARISON OF HYDROGEN MASER AND OF CESIUM BEAM TUBE FREQUENCY STANDARD  
NASA-TN-D-3292  
N66-21698
- CHARGE TRANSFER  
CHARGE TRANSFER AS LASER PUMPING TECHNIQUE  
A65-20063
- CHARGED PARTICLE  
FOCUSED LASER AS ACCELERATING CAVITY FOR CYCLIC PARTICLE ACCELERATOR  
A66-10328
- CHELATE COMPOUND  
LASER ACTION IN RARE EARTH CHELATES, EMPHASIZING CHEMISTRY AND SPECTROSCOPIC PROPERTIES OF MATERIALS AND PROPERTIES OF LIQUID LASER  
A65-20074
- OPTICAL PUMPING ENERGY TRANSFER MECHANISM IN RARE EARTH CHELATES NOTING POSSIBILITY AS LASER MATERIAL  
A65-20075
- EMISSION SPECTRA OF TRIS AND TETRAKIS FORMS OF FOUR BETA-DIKETONE EUROPIUM CHELATES STUDIED FOR LIQUID LASER APPLICATION  
A65-33308
- ENERGY TRANSFER IN RARE EARTH CHELATES - IMPLICATIONS FOR ORGANIC LASER DESIGN  
N65-15505
- RARE EARTH CHELATE LASERS  
N65-15508
- GAS LASER OSCILLATOR AND SOLID STATE CHELATE LASER
- RADC-TDR-64-442  
N65-16013
- ORGANIC CATIONS EFFECT ON LASER THRESHOLD OF SOLUTIONS OF TETRAKIS FORM OF EUROPIUM BENZOYLTRIFLUOROACETONATE  
A66-18418
- EMISSION SPECTROSCOPY AND COORDINATION CHEMISTRY OF EUROPIUM CHELATE SOLUTIONS - CHELATE LASERS INVESTIGATED FOR EVALUATING POTENTIALITIES OF LIQUID LASERS  
TR-65-052-11  
N66-14177
- COORDINATION AND CHEMICAL EQUILIBRIUM IN CHELATE LASER MATERIALS  
N66-20730
- CHEMICAL ANALYSIS  
LASER APPLICATION IN CHEMICAL COMPOSITION ANALYSIS OF MATERIAL BY SPECTROSCOPIC TECHNIQUE, CONSIDERING ORGANIC SUBSTANCE AND PLASMA  
A65-20004
- CHEMICAL EQUILIBRIUM  
COORDINATION AND CHEMICAL EQUILIBRIUM IN CHELATE LASER MATERIALS  
N66-20730
- CHEMICAL LASER  
CHEMICAL LASER WITH INPUT ENERGY DERIVED SOLELY FROM CHEMICAL REACTION PRODUCED RADIATION, NOTING PROCESS OF COHERENT LIGHT PRODUCTION  
A65-20001
- CHEMICAL LASER PRINCIPLE CONSIDERING POPULATION INVERSIONS FROM CHEMICAL REACTION  
A65-20002
- CONFERENCE ON CHEMICAL LASERS, UNIVERSITY OF CALIFORNIA AT LA JOLLA IN SEPTEMBER 1964  
A65-20059
- CHEMICAL PROCESSES PRODUCING SPECTROSCOPICALLY OBSERVABLE POPULATION INVERSIONS IN ATOMIC OR MOLECULAR LASERS  
A65-20066
- PARTIAL AND COMPLETE VIBRATIONAL-ROTATIONAL POPULATION INVERSION CONDITIONS, DISCUSSING VIBRATIONAL STATE CHANGE IN PHYSICAL AND CHEMICAL PROCESSES  
A65-20067
- VIBRATIONAL, ELECTRONIC AND TRANSLATIONAL ENERGY TRANSFERS OF GAS MOLECULE COLLISIONS, NOTING QUENCHING PROCESS AND FREQUENCY DIFFERENCES EFFECT  
A65-20068
- LASER OSCILLATION IN DECAY OF EXCITED MOLECULES FROM CHEMICAL REACTION, NOTING CHANGE IN THREE ELECTRONIC LEVELS IN MOLECULAR SYSTEM  
A65-20069
- FLAME EMISSION DATA AND ABSORPTION CHARACTERISTICS SUITABLE FOR POPULATION INVERSION FOR LASER ACTION, NOTING LOW PRESSURE OXYACETYLENE FLAME  
A65-20070
- OPTICAL PUMPING ENERGY TRANSFER MECHANISM IN RARE EARTH CHELATES NOTING POSSIBILITY AS LASER MATERIAL  
A65-20075
- SEMICONDUCTOR INJECTION LASERS AND LAMPS  
RAE-TR-65095  
N65-36334
- CHEMICAL PUMPING OF LASERS - EYE DAMAGE IN MONKEYS FROM LASER IRRADIATION  
U-3259  
N66-13799
- LIGHT EMISSION FROM GALLIUM ARSENIDE SEMICONDUCTOR P-N JUNCTION INJECTION LASER  
NOTS-TP-3655  
N66-19703
- ROOM TEMPERATURE OPERATION OF PULSED GALLIUM ARSENIDE INJECTION LASER, AND IMPROVEMENT OF LASER DIODE STRUCTURE  
ECOM-01501-1  
N66-20809
- CHEMICAL REACTION  
RARE EARTHS IN OPTICAL MASER MATERIALS, DISCUSSING CHEMICAL INTERACTIONS BETWEEN ACTIVE ION AND HOST LATTICE  
A65-17052
- RUBY LASER TEMPERATURE-JUMP RELAXATION KINETIC



- STUDIES OF RAPID REACTIONS  
UUCD-2-64 N66-23078
- CHINA  
SOLID STATE LASERS, ACOUSTICS, AND REGENERATION OF  
MUSCLE TISSUE - TRANSLATIONS OF CHINESE  
PEOPLES' REPUBLIC ARTICLES ON SCIENCE AND  
TECHNOLOGY  
JPRS-31817 N65-36115
- CHROMIUM  
CHROMIUM ALIGNMENT IN RUBY BY OPTICALLY PUMPING  
RUBY SAMPLE WITH CIRCULAR POLARIZED RADIATION FROM  
RUBY LASER A65-33418  
STIMULATED EMISSION FROM CHROMIUM IONS IN Q-  
SPOILED RUBY LASER A65-35066  
L-BAND TRAVELING-WAVE MASER FOR RADIO ASTRONOMY  
RESEARCH AT 21 CM USES CHROMIUM-DOPED RUTILE  
A66-16640
- CINEMATOGRAPHY  
TIME RESOLVED INTERFEROMETRY, CINEMATOGRAPHY, AND  
TRAVELING WAVE CAVITY STUDIES ON RUBY LASERS  
AFRL-65-467 N66-16656  
RUBY LASER RADIATION INTENSITY DISTRIBUTIONS BY  
HIGH SPEED CINEMATOGRAPHY AND TIME RESOLVED  
INTERFEROMETRY FOR PUMPED RADIATION EFFECTS  
N66-16657
- CIRCUIT  
LINEAR BEAM AND MICROWAVE POWER GENERATION - BEAM-  
CIRCUIT INTERACTION, BASIC CIRCUITS, BEAM-PLASMA  
AMPLIFIER, AND LASER-STIMULATED THERMIONIC  
EMISSION  
RADC-TR-65-22 N65-27099
- CIRCULAR POLARIZATION  
BEAT FREQUENCIES AND COHERENCE PROPERTIES IN  
CIRCULARLY POLARIZED ATOMIC TRANSITIONS OF GASEOUS  
LASERS WITH AXIAL MAGNETIC FIELDS A66-18429
- CLASSICAL MECHANICS  
QUANTUM AND CLASSICAL MECHANICAL THEORIES OF LASER  
RADIATION  
RM-4435-PR N65-19297  
LASER THEORY WITH CLASSICAL AND QUANTUM MECHANICAL  
APPROACH TO ABSORPTION AND EMISSION  
R-1743 N66-20857
- CLEAR AIR TURBULENCE  
LIGHT DETECTION AND RANGING / LIDAR/ TECHNIQUE USE  
IN ATMOSPHERIC RESEARCH, PARTICULARLY  
METEOROLOGICAL FACTORS IMPORTANT TO AVIATION AND  
ROCKET OPERATIONS  
AIAA PAPER 65-464 A65-30204  
AIRBORNE LASER-RADAR LIGHT DETECTION AND RANGING  
/ LIDAR/ SYSTEMS APPLIED TO DETECTION OF CLEAR AIR  
TURBULENCE / CAT/ A66-15297  
CLEAR AIR TURBULENCE DETECTION WITH LASER DOPPLER  
OPTICAL RADAR  
AIAA PAPER 66-374 A66-24498
- CLOCK  
COMPACT SOLID STATE CESIUM LASER BEAM FREQUENCY  
STANDARD FOR PRECISION CLOCKS N65-26681  
CAVITY TUNING OF AMMONIA MASERS BY PRESSURE AND  
ZEEMAN EFFECT MODULATION N65-26684
- CLOSED LOOP SYSTEM  
LASER BEAM COMMUNICATION BETWEEN DEEP-SPACE  
VEHICLE AND EARTH TRACKING STATION - CLOSED LOOP  
SYSTEM AND LEAD ANGLE COMPUTATIONS FOR TARGET  
MOTION COMPENSATION  
NASA-CR-60699 N65-16811
- COATING  
HELIUM-NEON LASER WITH SILVER AND DIELECTRIC  
COATING N65-20136
- COHERENT LIGHT  
COHERENT LASER BEAM USED TO SHOW CONSTANCY OF  
VELOCITY OF ELECTROMAGNETIC RADIATION A65-14215  
RELATIVITY VELOCITY SENSING TECHNIQUE FOR MOVING  
VEHICLE BY LASER LIGHT BACKSCATTERED FROM SURFACE  
A65-14934  
HYPERSONIC WAVE GENERATION BY SUPERPOSITION OF  
TWO COHERENT LIGHT BEAMS IN SOLID OR LIQUID  
DIELECTRIC A65-15880  
PHOTOELECTRONS EMITTED BY PHOTOCATHODE LIT BY HEAT  
SOURCE AND LASER COUNTING NUMBER OF AVALANCHES  
CURING GIVEN TIME A65-18037  
OPTICAL SECOND HARMONIC GENERATION APPLIED TO HIGH  
POWER COHERENT SOURCE FREQUENCY TRANSLATION IN  
COMMUNICATIONS SYSTEMS A65-19176  
RELATION BETWEEN QUANTUM AND SEMICLASSICAL  
DESCRIPTION OF OPTICAL COHERENCE, CONSIDERING  
DISTRIBUTION FUNCTION A65-21379  
SINGLE-ATOM COHERENCE EFFECTS IN MEASUREMENT OF  
SPONTANEOUS EMISSION LINewidthS IN HIGH-GAIN NEON  
LASER A65-21654  
RELATION BETWEEN OPTICAL COHERENCE AND PHOTON  
STATISTICS, USING CLASSICAL AND QUANTUM THEORY,  
INTERFERENCE EXPERIMENTS AND PHOTODETECTION  
A65-24002  
QUANTUM THEORY OF OPTICAL PUMPING CYCLE DEVELOPED  
FROM ANALYSIS OF EFFECTS OF LIGHT ON ATOMIC ENERGY  
LEVELS A65-24003  
VISUAL PERCEPTION OF INTENSE COHERENT IR  
RADIATION FROM GAS LASER A65-24083  
COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM  
OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE  
FABRY-PEROT RESONATOR A65-24088  
ACCURATE LOCATION OF OBJECT IN SPACE AND TIME AND  
CORRECTION OF MOVEMENTS BY USE OF QUANTUM  
ELECTRODYNAMICS A65-25036  
QUANTUM ELECTRONICS HISTORICAL REVIEW COVERING  
DIFFICULTIES ENCOUNTERED IN LASER/MASER  
CONSTRUCTION A65-25256  
LASER SYSTEM COHERENCE PROPERTIES OF STATISTICAL  
OPERATOR R IN LIGHT FIELD, USING SCHROEDINGER  
EQUATION ASSUMING GLAUBER STATE A65-25265  
INTEGRAL REPRESENTATION FOR ELECTROMAGNETIC FIELD  
IN FOCAL REGION OF COHERENT LIGHT BEAM EMERGING  
FROM APLANATIC OPTICAL SYSTEM A65-27092  
LASER BEAM INTERACTION WITH METAL FORM OF  
THERMAL, MULTIPLE PHOTON AND ELECTRIC FIELD EFFECT  
A65-27427  
COHERENT LASER LIGHT USED IN NEW PHOTOGRAPHIC  
PROCESS FOR RECORDING LIGHT WAVES INSTEAD OF IMAGE  
ON LIGHT-SENSITIVE FILM A65-28104  
MAGNETIC FIELD PROBE IN ELECTROMAGNETICALLY DRIVEN  
SHOCK TUBE AND COHERENT LIGHT IN IONIZING SHOCK  
WAVE PLASMA DIAGNOSTICS A65-29569  
DESIGN, OPERATION AND UTILIZATION OF LASER  
A65-29867  
LASER POWER DENSITY MEASURED WITH REDUCED  
ABSORPTION OF LIGHT BY METHYLENE BLUE, USING HE-  
NE CW LASER A65-31455  
LASER PROPERTIES, TECHNIQUES AND USES EMPHASIZING  
EMISSION MONOCHROMATICITY AND COHERENCE A65-32697  
SPIRAL FRINGES IN INTERFERENCE PATTERN OF  
INTERFEROMETER WITH LASER ILLUMINATION AS  
INDICATION OF DISCONTINUITY IN WAVE FRONT OR  
GENERATING SURFACE A65-33430  
MONOGRAPH ON THEORY OF COHERENCE IN OPTICS

# SUBJECT INDEX

# COHERENT RADIATION

INCLUDING CONCEPT OF DEGREE IN COHERENCE,  
COHERENCE IN QUASI-MONOCROMATIC LIGHT AND IN  
DIFFRACTION PHENOMENA A65-33897

VISUAL PERCEPTION OF INTENSE COHERENT IR  
RADIATION FROM GAS LASER A65-34904

COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM  
OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE  
FABRY- PEROT RESONATORS A65-35309

SYNCHRONIZED GENERATION OF RADIATION BY ALL  
SEMICONDUCTOR ELEMENTS OF LASER SYSTEM WITH  
RADIATIVE MIRRORS CAUSED BY DIFFRACTION OF  
ELECTROMAGNETIC FIELD A65-35279

BEAM DIVERGENCE AND FAR-FIELD PATTERNS OF RUB RODS  
OF VARYING OPTICAL QUALITY A65-35315

OPTICAL COHERENCE AND NONLINEAR INTERACTION OF  
LIGHT WAVES IN DIELECTRICS N65-21553  
REPT.-1579-17

SPECTRAL AND TRANSIENT CHARACTERISTICS OF SOLID  
STATE AND SEMICONDUCTOR LASERS, AND NONLINEAR  
INTERACTION OF COHERENT LIGHTWAVES DUE TO RAMAN  
EFFECT N65-21558  
S-702

COHERENT TRANSFER CHARACTERISTICS OF OPTICAL  
SYSTEM, HOLOGRAMS AND COMPLEX SPATIAL FILTERS,  
AND LASER APPLICATIONS N65-21691  
D-5210-72-T80-110

QUANTUM ELECTRODYNAMICS IN OPTICAL RESONATORS AND  
MASERS, THERMAL PINCHING, N-TYPE SEMICONDUCTORS,  
COHERENT LIGHT, TRANSISTOR SWITCHING, POPULATION  
INVERSION, AND BREAKDOWN N65-23491  
AFOSR-65-0248

MAXWELL EQUATIONS AS MATHEMATICAL MODELS FOR  
SOLUTION OF DIFFRACTION IMAGING THEORY OF  
COHERENT MONOCROMATIC LIGHT IN MICROSCOPY N65-23494

COHERENT LIGHT RECORDING AND REPRODUCING SYSTEM  
COMPRISING TWO-DIMENSIONAL QUANTUM MECHANICAL  
DATA PROCESS OF ULTIMATE PACKING DENSITY AND  
FREQUENCY BANDWIDTH N65-35528  
RADC-TR-65-130

INTERFERENCE EFFECTS AT THIN TRANSPARENT  
CYLINDRICAL GLASS FIBERS EXPOSED TO COHERENT LIGHT  
FROM HE- NE LASER A66-10368

COHERENCE THEORY FOR COLLIMATION AND FOCUSING OF  
TIME-AVERAGED INTENSITY OF PULSED MULTIMODE LASER  
RADIATION A66-12205

ULTIMATE SENSITIVITY LIMIT AND PHOTOELECTRON  
STATISTICS FOR PHOTOMULTIPLIER LIT BY COHERENT AND  
NONCOHERENT LIGHT A66-12473

BOOK ON MODERN OPTICS INCLUDING LASER AND COHERENT  
LIGHT, GEOMETRICAL OPTICS, LENS SYSTEMS,  
INSTRUMENTS, ETC A66-12623

PULSED IR LASER SIMULATING RADIATION-INDUCED  
TRANSIENT IONIZATIONS IN SEMICONDUCTOR DEVICES AND  
CIRCUITS A66-14853

SPONTANEOUS EMISSION NOISE EFFECTS ON COHERENCE  
PROPERTIES OF LASER A66-21550

EQUATIONS OBTAINED FROM HAMILTONIAN FOR COUPLING,  
FIRST STOKES LINE, FIRST ANTI- STOKES LINE AND  
COHERENT FIELD FOR RAMAN LASER A66-22490

COHERENT LASER LIGHT FOR CONVENTIONAL AND  
UNCONVENTIONAL PHOTOGRAPHIC SITUATIONS A66-22670

ABSOLUTE WAVELENGTH STABILITY OF HELIUM-NEON LASER  
MEASURED BY DIRECT INTERFEROMETRIC COMPARISON WITH  
HG 198 STANDARD LAMP A66-22868

TWO-BEAM INTERFEROMETRY BY WAVEFRONT  
RECONSTRUCTION FROM HOLOGRAM RECORDED WITH

COHERENT BACKGROUND SUCCESSIVELY INTERFERE IN SAME  
LATENT IMAGE A66-23204

SPONTANEOUS EMISSION FROM ATOM INTERACTING WITH  
COHERENT LIGHT WAVE N66-12043  
AFOSR-65-1000

OPTICAL MARGINAL OSCILLATOR DEVELOPMENT IN  
RESEARCH TOWARD TUNABLE COHERENT LIGHT SOURCE  
REPT.-8071 N66-14034

SPECTRAL EMISSION CHARACTERISTICS OF LASER  
COHERENT OSCILLATOR N66-16742

GALLIUM ARSENIDE LASER DIODES WITH HIGH OUTPUT  
COHERENT BEAM FOR COMMUNICATIONS SYSTEMS N66-21293  
ECOM-2629

COHERENT LIGHT COMMUNICATION SYSTEM FOR ATMOSPHERE  
CONDITION EFFECTS ON FREQUENCY MODULATED LASER  
BEAM N66-21774  
FR-66-14-37

COHERENT RADAR  
SOLID STATE LASER AND PHASE SHIFTER DESIGN FOR  
COHERENT OPTICAL RADAR N65-17148  
AB-1272-0016-2

COHERENT RADIATION  
LASER EMISSION FROM N TYPE GALLIUM ARSENIDE  
CRYSTAL BY FAST ELECTRON EXCITATION, NOTING DOPING  
AND EMISSION ENERGY A65-19546

COHERENCE PROPERTIES OF INTERACTING SYSTEM OF  
RADIATION AND MATTER EXHIBITING LASER-LIKE  
BEHAVIOR, NOTING SELF-CONSISTENT-FIELD  
APPROXIMATION / SCFA/ USE FOR MANY-BODY EFFECTS  
A65-27725

MASER-LASER THEORY AND APPLICATION A65-32621

TRUNCATED EQUATIONS DESCRIBING COHERENT RADIATION  
OF EXCITED CHROMIUM IONS IN RUBY SITUATED IN  
TRAVELING WAVE RESONATOR A65-35919

HISTORY AND DEVELOPMENT OF MOLECULAR AMPLIFICATION  
BY STIMULATED EMISSION OF RADIATION, NOTING  
VARIOUS LASER TYPES A65-36095

GALLIUM ARSENIDE LUMINESCENT DIODES WITH  
TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION  
AT HIGH DENSITY CURRENT A65-36787

COHERENCE PROPERTIES OF HELIUM-NEON LASER WITH  
SUPERIMPOSED MODES EXAMINED BY INTERFERENCE  
PATTERN A66-10337

SHARPLY DIRECTIONAL COHERENT RADIATION GENERATION  
BY SYNCHRONIZED LASERS OR MULTIMIRRORED RESONATOR  
OF SINGLE LASER A66-11007

OPTICALLY CONNECTED LASER CONSTRUCTED ON GALLIUM  
ARSENIDE P-N JUNCTION, NOTING COHERENT RADIATION  
A66-14363

HISTORY AND DEVELOPMENT OF MOLECULAR AMPLIFICATION  
BY STIMULATED EMISSION OF RADIATION, NOTING  
VARIOUS LASER TYPES A66-15034

BEAT FREQUENCIES AND COHERENCE PROPERTIES IN  
CIRCULARLY POLARIZED ATOMIC TRANSITIONS OF GASEOUS  
LASERS WITH AXIAL MAGNETIC FIELDS A66-18429

LASER EMISSION IN PURE CADMIUM SULFIDE CRYSTALS  
BOMBARDED BY ELECTRON BEAMS A66-18650

GALLIUM ARSENIDE LUMINESCENT DIODES WITH  
TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION  
AT HIGH DENSITY CURRENT A66-19195

SHARPLY DIRECTIONAL COHERENT RADIATION GENERATION  
BY SYNCHRONIZED LASERS OR MULTIMIRRORED RESONATOR  
OF SINGLE LASER A66-19945

PULSE EXCITATION OF VOLUME OF GAS TO COHERENTLY  
RADIATING STATE APPLIED TO BEAM MASER SPECTROMETER  
A66-23731

## COHERENT SCATTERING

## SUBJECT INDEX

## COHERENT SCATTERING

COHERENT LIGHT DIFFRACTION BY MICROWAVE SOUND IN  
TRANSPARENT CRYSTALS A65-29265

## COHERENT TRANSMISSION

OPTICAL COHERENT WAVE PROPERTIES SUITABLE FOR LONG  
DISTANCE LASER COMMUNICATIONS AND COMPARED WITH  
RADIO WAVE CHARACTERISTICS A65-20006

DETECTOR AND SOURCE APERTURE DIMENSIONAL CRITERIA  
FOR MAINTAINING LONG RANGE LASER BEAM COHERENCE IN  
TURBULENT AIR A65-28016

## COLD CATHODE

ALUMINUM COLD CATHODES WITH SINGLE MODE  
6328 ANGSTROM HELIUM-NEON GAS LASER LIFETIMES  
EXCEEDING 3000 HOURS A66-10855

## COMBUSTION INSTABILITY

COMBUSTION INSTABILITY, BALL LIGHTNING, SOLAR  
ACTIVITY, NOCTILUCENT CLOUDS, INTERSTELLAR  
COMMUNICATIONS, NEODYMIUM LASER, AND HYDROFOILS  
N65-34075

## COMBUSTION WAVE

ONSET OF RETONATION, LASER TECHNOLOGY AND HIGH  
REPETITION-HIGH RESOLUTION SCHLIEREN STROBOSCOPIC  
WAVE PHENOMENA RECORDS A66-19200

## COMMUNICATION

PROPERTIES OF LASERS AND APPLICATION TO  
SCIENTIFIC INSTRUMENTATION, COMMUNICATIONS,  
BIOLOGY, PRECISION MEASUREMENTS, METAL WORKING,  
AND MISCELLANEOUS AREAS  
AFCLRL-64-914 N65-16002

HIGH VOLTAGE, POWER, AND ENERGY FACILITIES FOR  
RADAR, LASERS, PLASMAS, AND COMMUNICATION  
COMPONENTS RESEARCH  
EB-5288-0536 N65-21673

EFFECTS OF PROPAGATION TIMES ON STEERING NARROW  
BEAM LASER FOR COMMUNICATIONS BETWEEN PLANETARY  
DEEP-SPACE VEHICLE AND EARTH GROUND STATION OR  
RELAY STATION - SPACIAL BEAM OFFSET  
NASA-TM-X-55306 N66-11202

## COMMUNICATION SYSTEM

ATMOSPHERIC TURBULENCE EFFECT ON OPERATION OF  
DUAL-POLARIZATION FM LASER COMMUNICATION SYSTEM  
A65-33377

LASER COMMUNICATION SYSTEMS STUDY  
FR-64-19-301 N65-17940

DATA PULSED TRANSMISSION OVER ELECTRON-INJECTION  
LASER COMMUNICATION SYSTEM, USING CONTINUOUS WAVES  
A66-19934

OPTICAL COMMUNICATION SYSTEMS - LASER THEORY AND  
APPLICATION TO COMMUNICATIONS  
FTD-TT-65-95/1828364 N66-12120

JUSTIFICATION GIVEN FOR USING 10 MICRON WAVELENGTH  
IN DEEP SPACE LASER COMMUNICATION SYSTEM  
NASA-TM-X-55396 N66-17234

LASER COMMUNICATION TRANSMITTERS FOR GT-7 GEMINI  
EXPERIMENTS  
NASA-CR-65246 N66-20941

SPACE-TO-SPACE AND EARTH-TO-SPACE COMMUNICATION  
SYSTEMS USING LASER SOURCES  
RADC-TDR-64-289 N66-22582

RESEARCH REVIEW OF OPTICAL TRACKING, GUIDANCE, AND  
COMMUNICATION STUDIES AT MSFC N66-23457

## COMMUNICATION THEORY

PHYSICAL ELECTRONICS, SOLID STATE PHYSICS, LIQUID  
STATE PHYSICS, INFORMATION SCIENCES, AND LASER  
AND COMMUNICATION THEORY  
LMSC-6-75-65-10 N65-25125

## COMMUNICATIONS DEVICE

LASER BEAM COMMUNICATION BETWEEN DEEP-SPACE  
VEHICLE AND EARTH TRACKING STATION - CLOSED LOOP  
SYSTEM AND LEAD ANGLE COMPUTATIONS FOR TARGET  
MOTION COMPENSATION

NASA-CR-60699

N65-16811

## COMMUNICATIONS SATELLITE

LIFE SUPPORT SYSTEM, FLUID AMPLIFICATION,  
SPALLING, COMMUNICATIONS SATELLITE, MICROWAVE  
APPARATUS, HIGH STRENGTH STEEL, TRACERS, LASERS,  
ATMOSPHERIC TURBULENCE, AND RESONANCE  
AD-611432 N65-22732

GC/S NITROGEN-COOLED NONDEGENERATE PARAMETRIC  
AMPLIFIER, NOTING DESIGN, APPLICATION AND  
OPERATION CHARACTERISTICS A66-21857

## COMPOSITE PROPELLANT

SELECTED FOREIGN SCIENTIFIC AND TECHNICAL  
LITERATURE ON POTENTIAL THEORY, SEMICONDUCTOR  
LASERS, COMPOSITE PROPELLANTS, AROMATIC,  
POLYESTERS, AND TECTONICS N66-21862

## COMPTON EFFECT

COMPTON SCATTERING OF LASER PHOTONS, NOTING  
TRANSFORMATION INTO GAMMA RADIATION PHOTONS UPON  
COLLISION WITH HIGH ENERGY ELECTRONS  
A66-17816

STIMULATED COMPTON SCATTERING OF ELECTRONS BY  
LASER BEAM  
IS-1187 N66-20388

## CONFERENCE

PROCEEDINGS OF INTERNATIONAL SYMPOSIUM ON LASER  
PHYSICS AND APPLICATIONS AT BERN, SWITZERLAND  
IN OCTOBER 1964 A65-19993

CONFERENCE ON CHEMICAL LASERS, UNIVERSITY OF  
CALIFORNIA AT LA JOLLA IN SEPTEMBER 1964  
A65-20059

PROCEEDINGS OF URSI GENERAL ASSEMBLY ON RADIO  
ELECTRONICS INCLUDING PLASMAS, MASERS AND LASERS  
AT TOKYO IN SEPTEMBER 1963 A65-26930

NINETEENTH ANNUAL CONVENTION OF ARMED FORCES  
COMMUNICATIONS AND ELECTRONICS ASSOCIATION ON  
LASER TECHNOLOGY AND APPLICATION AT FORT  
MONMOUTH, NEW JERSEY IN JUNE 1965  
A65-31879

ORGANIC LASER CONFERENCE  
TR-64-052.6 N65-15502

LIFE SUPPORT SYSTEM, FLUID AMPLIFICATION,  
SPALLING, COMMUNICATIONS SATELLITE, MICROWAVE  
APPARATUS, HIGH STRENGTH STEEL, TRACERS, LASERS,  
ATMOSPHERIC TURBULENCE, AND RESONANCE  
AD-611432 N65-22732

LASER PHYSICS CONFERENCE - ENERGY EXCHANGE IN  
SOLIDS AND GASES, NONLINEAR EFFECTS, GAS  
BREAKDOWN, AND REFRACTIVE INDEX VARIATION  
AD-622507 N66-14573

CONFERENCE ON PHYSICAL PROBLEMS OF QUANTUM  
ELECTRONICS - NONLINEAR OPTICAL PHENOMENA,  
SEMICONDUCTOR LASERS, GAS DISCHARGES IN GAS  
LASERS, AND GAS BREAKDOWN IN LASER BEAM  
JPRS-34262 N66-18135

## CONTAMINATION

LASER FLOW METER FOR MEASUREMENT OF LOCAL VELOCITY  
IN CONTAMINATED GAS FLOW FIELDS - DOPPLER SHIFT  
TECHNIQUE  
R-149 N65-26015

## CONTINUOUS WAVE

FABRICATION AND TEST OF CONTINUOUS WAVE LASER  
ACTION FROM DYSPROSIUM IN CALCIUM FLUORIDE EXCITED  
BY TUNGSTEN LAMP A65-19184

KINETIC EQUATION TO DESCRIBE CONTINUOUS WAVE LASER  
RADIATION INSTABILITY A65-19739

LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO  
DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF  
SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS  
A65-24879

PUMPING POWER FORMULA FOR DETERMINING  
CHARACTERISTICS OF CONTINUOUS WAVE AND PULSED

## SUBJECT INDEX

## CROSS CORRELATION

- LASERS** A65-26687 A66-11190
- OPTICAL SECOND HARMONIC GENERATION ANGULAR VARIATION IN AMMONIUM DIHYDROGEN PHOSPHATE GAUSSIAN CW GAS LASER BEAM FOR NONLINEAR COEFFICIENT MEASUREMENTS A65-27724 A66-24011
- C W HIGH POWER OPERATION OF NITROGEN-CARBON DIOXIDE LASER OSCILLATING ON P-BRANCH ROTATIONAL TRANSITIONS OF VIBRATIONAL BAND OF CARBON DIOXIDE A65-33055 A66-18357
- INTENSITY FLUCTUATIONS MEASURED IN EMISSION FROM VARIOUS LASING AND NONLASING MODES OF CONTINUOUS WAVE GA AS LASER A65-34687
- LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS A65-36356
- INTERNAL TUNING METHODS FOR CONTINUOUS WAVE LASERS OVER ANGSTROM BANDWIDTHS SEL-64-092 N65-14369
- CONTINUOUS WAVE GAS LASER AND HIGH SPEED MOTION PICTURE CAMERA FOR DETECTION OF NEARLY CONTINUOUS SET OF LIGHT SCATTERING PHOTOGRAPHS FROM POLYETHYLENE POLYMER SAMPLE ONR-TR-77 N65-25399
- EXPERIMENTS ON OPERATING LIFE AND TRANSVERSE MODE HOPPING IN CONTINUOUS WAVE RUBY LASER IER-7 N65-33421
- HIGH POWER BREWSTER WINDOW LASER WITH GAS FILLS, DISCUSSING POWER OUTPUT AND EFFICIENCY PARAMETERS A66-13983
- TRIMMING MICROCIRCUIT ELEMENTS LIKE EVAPORATED THIN-FILM AND SILK-SCREENED CERMET-FILM RESISTORS ATTEMPTED WITH CW AND PULSED LASERS A66-14562
- PUMPING POWER FORMULA FOR DETERMINING CHARACTERISTICS OF CONTINUOUS WAVE AND PULSED LASERS A66-15900
- INTENSITY FLUCTUATIONS IN OUTPUT OF FOUR-LEVEL CW LASER OSCILLATORS BY LINEARIZED RATE EQUATIONS A66-18434
- DATA PULSED TRANSMISSION OVER ELECTRON-INJECTION LASER COMMUNICATION SYSTEM, USING CONTINUOUS WAVES A66-19934
- OUTPUT POWER OF CW LASER MEASURED BY WIRE BOLOMETER IN FORM OF PLANE SINGLE-LAYER SPIRAL AS SENSITIVE ELEMENT A66-20364
- OPTICAL SECOND HARMONIC GENERATION IN FOCUS OF LOWEST TRANSVERSE MODE OF CONTINUOUS WAVE GAUSSIAN GAS LASER BEAM A66-21175
- C W LASER ACTION ON TRIPLE STATE PHOSPHORUS-SULFUR TRANSITION, USING HYDROGEN SULFIDE-MOBLE GAS MIXTURES A66-21577
- CURRENT-VOLTAGE CHARACTERISTICS OF CW X-BAND GA AS MICROWAVE GUNN GENERATOR A66-23029
- CONTINUOUS WAVE MEASUREMENT OF OPTICAL NONLINEARITY OF AMMONIUM DIHYDROGEN PHOSPHATE, USING HELIUM-NEON LASER A66-23716
- CONTINUOUS WAVE GAS LASER DOPPLER FLOW METER FOR GAS VELOCITY MEASUREMENT N66-22338
- CONTINUOUS WAVE /CW/ RADAR**
- DOPPLER OPTICAL NAVIGATOR TO MEASURE INSTANTANEOUS GROUND SPEED WITH 0.1 FT/SEC ACCURACY FOR ALTITUDES OF 250 TO 5000 FEET - CONTINUOUS WAVE LASER AS TRANSMITTER TRG-019-1-2 N65-28160
- CONTINUUM RADIATION**
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION LASER COOLED BY HELIUM GAS FLOW
- CONTROL SYSTEM**
- FREQUENCY STABILIZATION OF GAS LASERS, USING ATOMIC RESONANCE AND INTERFEROMETERS A66-18357
- CORRELATION COEFFICIENT**
- CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY LASER A65-35866
- CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY LASER A66-19269
- CORRELATION FUNCTION**
- QUANTUM THEORETICAL ANALYSIS OF LASER BEAM FLUCTUATIONS AND OF LIGHT BEAT EXPERIMENTS WITH TWO LASERS A65-25059
- NONLINEAR THEORY OF LASER NOISE WITH CORRELATION FUNCTIONS DERIVED FROM DISTRIBUTION FUNCTIONS OBTAINED BY FOKKER-PLANCK EQUATION A65-27759
- CORRELATION FUNCTIONS OF AMPLITUDE AND INTENSITY FLUCTUATION FOR LASER MODEL NEAR THRESHOLD OBTAINED BY USING DISTRIBUTION FUNCTIONS EVALUATED BY FOKKER-PLANCK EQUATION, TREATING AMPLITUDE AS RANDOM VARIABLE A66-25018
- CORROSION**
- FLUID MECHANICS, LUBRICATION, CORROSION, MASERS, BIOLOGICAL STRESS, PROTECTIVE COATINGS, NEUTRON ACTIVATION, FRACTOGRAPHY, METABOLISM, GUIDED MISSILE LAUNCHING, AND CATAPULTS AD-623630 N66-14468
- COUNTER**
- DIGITAL TIME-INTERVAL COUNTER /RANGEMETER/ FOR USE WITH LASER RANGEFINDER HDL-TR-1262 N65-14460
- COUPLED MODE**
- OPTICAL CAVITY IN WHICH MODES ARE DETERMINED AS STATIONARY STATES OF DIFFRACTION-LIMITED OBJECT/ IMAGE TRANSFORMATION OF CLASSICAL OPTICS A65-18013
- EXPERIMENTAL OSCILLATION OF TWO LASERS AT SAME FREQUENCY WITH PHASE DIFFERENCE OF LESS THAN ONE THIRD DEGREE A65-19603
- MODE LOCKING IN HELIUM-NEON LASER BY MEANS OF SYNCHRONOUS INTRACAVITY ACOUSTIC MODULATION IN COUPLED MULTIMODE CONFOCAL INTERFEROMETERS A65-24276
- LASER OPERATION AS PULSED REGENERATIVE OSCILLATOR ARISING FROM MODE COUPLING DUE TO TIME-VARYING LOSS IN CAVITY OR NONLINEAR CHARACTERISTICS OF INVERTED POPULATION A65-27603
- STABILITY OF CORRECTED COUPLED-MODE LASER EQUATION DERIVED FROM MODEL FOR RUBY LASER SPIKING RESULTING FROM MODE INTERFERENCE A65-29805
- COUPLING**
- TIME DEPENDENCY OF COUPLED MODE LASER OSCILLATION UCRL-7497 N66-20355
- CRACK FORMATION**
- PARALLEL GROOVES AS SURFACE DAMAGE IN SEMICONDUCTORS PRODUCED BY RUBY LASER AS DIFFRACTION EFFECT A66-13753
- FRACTURES IN NEODYMIUM-DOPED ALKALINE SILICATES AND BOROSILICATES PRODUCED BY LASER BEAM A66-14174
- CROSS CORRELATION**
- CROSS CORRELATION MEASUREMENTS OF OSCILLATOR FREQUENCY STABILITY AND THERMAL NOISE AND

## CROSS RELAXATION

## SUBJECT INDEX

APPLICATION TO ATOMIC HYDROGEN MASER  
A66-24128

**CROSS RELAXATION**  
PHENOMENOLOGICAL TREATMENT OF SATURATION EFFECTS  
IN SOLID STATE LASER AMPLIFIERS  
A65-18887

PUMP FREQUENCY OF 30 GIGACYCLES USING HARMONIC  
CROSS RELAXATION ON CHROMIUM DOPED RUTILE TO  
OBTAIN POPULATION INVERSION AT 40 GIGACYCLE  
SIGNAL FREQUENCY  
A65-25873

**CROSSED FIELD**  
LASER ACTION AT 5401 ANGSTROMS IN PURE NEON PULSED  
HIGH VOLTAGE DISCHARGE  
A66-10353

**CRYSTAL**  
ELECTRON BEAM PENETRATION IN LASER CRYSTALS FROM  
DATA OF KING AND EHRENBURG  
A65-22627

IMPROVEMENT OF CRYSTAL QUALITY OF FLAME FUSION  
RUBY - LASER MATERIAL  
AL-TDR-64-195, PT. I  
N65-15848

CRYSTALS FOR OPTICAL MASER APPLICATION  
PE-TR-M7920  
N65-16442

MICROWAVE RESEARCH ON ACOUSTIC WAVE AMPLIFICATIONS  
AND GEOMETRICAL OPTICS, OPTICAL MASERS,  
ELECTRON-PHONON INTERACTIONS, AND RAMAN  
SCATTERING FROM BIREFRINGENT CRYSTALS  
ML-1277  
N65-20038

SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION,  
CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION,  
FREQUENCY MODULATION LASERS, AND GALLIUM  
COMPOUND INGOTS FOR LASER APPLICATION  
AFCL-64-1007  
N65-23135

PHONON INTERACTION IN CRYSTALS - TRANSIENTLY  
OPERATED ACOUSTIC MASER, INTERACTION OF PHONONS  
WITH IMPURITIES IN GERMANIUM AND SILICON, AND  
HEAT PULSES IN CRYSTALS  
QTR-7  
N65-27746

SHOCK TUBE LASER PUMPING - FOUR COMBINATIONS  
OF LASER CRYSTAL AND PUMPING CONFIGURATION  
U-3104  
N65-28154

**CRYSTAL GROWTH**  
CRYSTAL GROWTH AND PREPARATION OF POTENTIAL LASER  
MATERIAL CONTAINING RARE EARTH IONS AS DOPANTS  
A65-17042

ENERGY OUTPUT INCREASE OF RUBY LASER CRYSTAL  
SYSTEMS BY NUCLEAR ENERGY, LASER CRYSTAL GROWTH,  
AND SURFACE FINISH DEVELOPMENT  
AD-455571  
N65-17595

LASER CRYSTAL GROWTH, CHARACTERIZATION, AND  
SURFACE FINISHING  
N65-17597

GROWTH OF NEW CRYSTAL MATERIALS FOR LASERS -  
SPECTRAL ANALYSIS USING FLAME FUSION,  
CZOCHEWALSKI, FLUX, AND VAPOR TECHNIQUES  
M7881  
N65-19354

CRYSTAL GROWTH OF INORGANIC OXIDES FOR LASER  
APPLICATIONS  
AD-611416  
N65-22952

GROWTH OF RUBY BOULES ON 60 DEGREE VERNEUIL RODS  
BY CZOCHEWALSKI METHOD - LASER APPLICATION  
SRCR-65-1  
N65-27885

GROWTH OF BROAD LINEWIDTH RUBY SINGLE CRYSTALS  
FROM FLUX AND ADDITION OF GALLIUM FOR HIGH  
OPTICAL LASERS  
R-11-454  
N65-28525

RUBY LASER CRYSTALS GROWN BY FLAME-FUSION, FLUX  
AND CZOCHEWALSKI METHOD EXAMINED FOR PERFECTION BY  
X-RAY TOPOGRAPHY AND DOUBLE-CRYSTAL ROCKING  
CURVES  
A66-13744

APPARATUS FOR FLUORIDATION OF HYDROXYL AND OXYGEN  
CONTAMINATED FLUORIDE COMPOUNDS, OBTAINING  
OPTICALLY CLEAR CRYSTALS WITH NO TYNDALL

SCATTERING FOR LASER APPLICATION  
A66-18488

CRYSTAL GROWTH, LATTICE CONSTANT, AND DENSITY OF  
MAGNESIUM POTASSIUM FLUORIDE AND BARIUM  
ZIRCONATE  
AD-623511  
N66-14467

GROWTH OF CUBIC PEROVSKITE CRYSTALS AS SYMMETRIC  
HOSTS FOR LASER DOPANT IONS  
SRCR-65-9  
N66-16824

GROWTH AND ANNEALING OF OPTICAL MASER CRYSTALS AND  
SPECTROSCOPIC EVALUATION OF NEODYMIUM-DOPED  
GLASSES  
PE-TR-8110  
N66-17007

RUBY GROWTH PROCESS FOR RANGEFINDER LASER RODS  
QPR-1  
N66-19918

ELECTRON BEAM AND HOLLOW CATHODE FLUAT-ZONE  
PROCESSES ANALYSIS FOR APPLICATION TO GROWTH OF  
LASER RUBY CRYSTALS  
AFCL-65-908  
N66-21169

LASER MODULATOR USING GALLIUM ARSENIDE AND GALLIUM  
PHOSPHIDE ELECTRO-OPTIC CRYSTALS  
NASA-CR-71516  
N66-21435

SEMICONDUCTOR INJECTION LASER FOR CONTINUOUS  
OPERATION AT ROOM TEMPERATURE IN VISIBLE  
WAVELENGTH RANGE  
NASA-CR-74018  
N66-23746

VAPOR PHASE GROWTH OF RUBY SINGLE CRYSTALS FOR  
LASER APPLICATIONS  
AD-629154  
N66-23875

**CRYSTAL LATTICE**  
RARE EARTHS IN OPTICAL MASER MATERIALS, DISCUSSING  
CHEMICAL INTERACTIONS BETWEEN ACTIVE ION AND HOST  
LATTICE  
A65-17052

**CRYSTAL OPTICS**  
OPTICAL AND LASER THRESHOLD MEASUREMENTS ON 39  
FLAME-FUSION RUBIES TO OBTAIN HIGHEST OPTICAL  
QUALITY LASER RODS  
A65-16402

SYSTEM TRANSLATING FREQUENCY OF GAS LASER OVER  
RANGE OF SEVERAL GIGACYCLES, ELIMINATING NEED FOR  
ELECTRO-OPTIC CRYSTALS WITH CUBIC SYMMETRY  
A65-25872

SECOND HARMONIC EMISSION AND DIFFRACTION PHENOMENA  
IN KDP CRYSTAL EXCITED BY RUBY LASER BEAM  
A65-29559

CRYSTALLINE CALCITE USED AS DICHROIC POLARIZER IN  
IR REGIONS, LASER RADIATION, ZEEMAN EFFECT AND  
NOISE PROPERTIES MEASUREMENTS, ETC  
A65-33419

U V RADIATION STIMULATED EMISSION IN OPTICALLY  
PUMPED POTASSIUM BROMIDE CRYSTALS USEFUL FOR LASER  
EMISSION WHICH IS CONSISTENT WITH POPULATION  
INVERSION EXCITON SCHEME  
A65-35069

OPTICAL RECTIFICATION IN CRYSTALS USING RUBY  
LASER BEAM  
TID-21807  
N65-35445

EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING  
SPECTRAL RANGE, DURATION, ELECTRON EXCITATION  
MECHANISM AND UPPER WAVELENGTH LIMIT  
A66-19667

EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING  
SPECTRAL RANGE, DURATION, ELECTRON EXCITATION  
MECHANISM AND UPPER WAVELENGTH LIMIT  
A66-21834

ELECTRON BEAM PUMPED LASERS, DISCUSSING ENERGY  
DISSIPATION IN FAST ELECTRONS PASSING THROUGH  
CRYSTAL, LASER SEMICONDUCTOR CHARACTERISTICS, ETC  
A66-23433

**CRYSTAL STRUCTURE**  
OPTICAL SECOND HARMONIC GENERATION ANGULAR  
VARIATION IN AMMONIUM DIHYDROGEN PHOSPHATE

# SUBJECT INDEX

# DEFLECTION

GAUSSIAN CW GAS LASER BEAM FOR NONLINEAR  
COEFFICIENT MEASUREMENTS A65-27724

LASER CRYSTAL GROWTH, CHARACTERIZATION, AND  
SURFACE FINISHING N65-17597

SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION  
PROPERTY CHANGES DUE TO PULSED RUBY LASER  
RADIATION A66-15354

SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION  
PROPERTY CHANGES DUE TO PULSED RUBY LASER  
RADIATION A66-20895

LASER CRYSTALS PREPARED ECONOMICALLY BY SPLITTING  
ALONG CLEAVAGE PLANES A66-23293

OPTICAL MASER OF TRIVALENT NEODYMIUM IN TUNGSTATE  
CRYSTALS N66-15045

CRYSTAL STRUCTURE DEFECT  
RUBY LASER CRYSTAL FLAWS OF CLOSELY PACKED  
SPHEROIDS SUGGESTING PLASTIC FLOW AND QUENCH-IN AS  
CAUSE A65-17684

CRYSTALLIZATION  
RESEARCH IN CHINESE PEOPLES REPUBLIC - SOLAR  
FLUX, GAS DISCHARGE TUBE, NEODYMIUM LASER,  
GEOLOGICAL MECHANICS, MICROCRYSTALLINE GLASS,  
LOCATING OF THUNDER, AND PURIFICATION WITH  
DISTILLATION METHODS N66-16806  
JPRS-33759

CRYSTALLOGRAPHY  
POSSIBLE MATERIALS FOR SECOND HARMONIC GENERATION  
AND LASER ACTION DISCUSSING CENTROSYMMETRIC AND  
PIEZOELECTRIC CRYSTALS AND SINGLE CRYSTAL PLATE  
WITH ALTERNATE LAYERS OF NONCENTROSYMMETRIC  
COMPOSITION A66-12940

LASER CRYSTALS PREPARED ECONOMICALLY BY SPLITTING  
ALONG CLEAVAGE PLANES A66-23293

CUBIC CRYSTAL  
PEROVSKITE LASER HOST MATERIALS HAVING CUBIC  
CENTROSYMMETRIC CRYSTAL LATTICE SITES  
UACRL-D910269-5 N65-35429

CURRENT DENSITY  
EXCITATION OF SEMICONDUCTOR LASERS BY BEAM OF FAST  
ELECTRONS, DISCUSSING WORK OF SHOCKLEY, POPOV,  
KELDYSH AND KROKHIN A66-17337

CURRENT DISTRIBUTION  
CURRENT DISTRIBUTION CONTROL IN GALLIUM ARSENIDE  
INJECTION LASER SHOWING EFFECTS ON OSCILLATION  
MODE AND THRESHOLD A65-17665

CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER A66-10704

GALLIUM ARSENIDE P-N JUNCTION LASER DIODE COVERING  
INJECTION CURRENT DISTRIBUTION, DENSITY AND  
EMISSION SPECTRA VARIATION A66-14659

CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER A66-23309

CYANIDE  
LASER TRANSITION IN VIBRATIONAL STATE OF GROUND  
ELECTRONIC STATE OF CN FROM ROTATIONAL LEVEL 8 TO  
7 WITH POPULATION INVERSION AS RESULT A66-11451

CYCLIC ACCELERATOR  
FOCUSED LASER AS ACCELERATING CAVITY FOR CYCLIC  
PARTICLE ACCELERATOR A66-10328

CYCLOTRON RESONANCE  
MICROWAVE ELECTRON CYCLOTRON RESONANCE PUMPING OF  
NEON-HELIUM LASER TO RAISE PLASMA ELECTRON  
TEMPERATURE FOR INCREASE OF OUTPUT A65-15320

INTERACTION OF ENERGETIC ELECTRONS WITH BOUNDED  
ELECTROMAGNETIC WAVES NEAR CYCLOTRON RESONANCE,  
NOTING PLASMA DIAGNOSTICS, MASER AND GAIN

MECHANISM A66-13953

CYLINDER  
STUDIES ON RADIATION PROTECTION FOR MAN, OPTICAL  
MASER OF NEODYMIUM IN TUNGSTATE, CYLINDER WAVE  
PROPAGATION ANALYSIS, AND ELECTROMOTIVE FORCE OF  
INDIUM ANTIMONIDE COMPOUND N66-15042  
JPRS-33152

## D

DATA LINK  
LASER COMMUNICATIONS LINK SECURITY AGAINST  
INTERCEPTION, EXAMINING FREQUENCY BANDWIDTH FOR  
MINIMUM SNR A66-16650

DATA PROCESSING  
DEVELOPMENT IN U.S. OF LASER APPLICATION WITH  
TABLE INCLUDING GOVERNMENT SUPPORTED PROGRAMS IN  
PHOTOGRAPHY, DATA PROCESSING, RADAR, ETC A66-11455

OPTICAL DATA PROCESSING TECHNIQUES CONSIDERING  
STORAGE, MANIPULATION, HOLOGRAPHY AND PATTERN  
RECOGNITION USING MATCHED FILTERS A66-12997

GLASS FIBER LASERS FOR OPTICAL DATA PROCESSING  
AORC-4502-16-564-42 N66-11060

DATA TRANSMISSION  
DATA PULSED TRANSMISSION OVER ELECTRON-INJECTION  
LASER COMMUNICATION SYSTEM, USING CONTINUOUS WAVES  
A66-19934

FACILITIES AND EQUIPMENT AT GOONHILLY DOWNS  
SATELLITE SYSTEM GROUND STATION - STEERABLE  
ANTENNA, COMPUTING AND DATA TRANSMISSION, AND  
HELIUM SYSTEM FOR MASER INSTALLATION N66-10260

DECAY  
DECAY OF LASER-INDUCED EXCITATIONS OF F CENTERS  
IN ALKALI HALIDES N65-34867  
MSC-387

DECAY RATE  
MEASUREMENT OF GAS LASER RADIATIVE DECAY RATES AND  
TOTAL INELASTIC DESTRUCTIVE CROSS SECTION OF SHORT  
LIVED EXCITED STATES IN 4-NSEC TO 1000-NSEC RANGE  
A65-20061

DEEP SPACE  
EFFECTS OF PROPAGATION TIMES ON STEERING NARROW  
BEAM LASER FOR COMMUNICATIONS BETWEEN PLANETARY  
DEEP-SPACE VEHICLE AND EARTH GROUND STATION OR  
RELAY STATION - SPACIAL BEAM OFFSET N66-11202  
NASA-TM-X-55306

JUSTIFICATION GIVEN FOR USING 10 MICRON WAVELENGTH  
IN DEEP SPACE LASER COMMUNICATION SYSTEM N66-17234  
NASA-TM-X-55396

DEFENDER PROJECT  
CHELATE LASER SYSTEMS - EUROPIUM BENZOYLACETONATE  
TR-64-052.7 N65-14405

DOUBLE PHOTON ABSORPTION, HARMONIC GENERATION,  
AND FREQUENCY MIXING IN SEMICONDUCTORS, AND  
FREQUENCY TUNING OF INJECTION LASERS BY  
UNIAXIAL STRESS N65-14437  
AD-450756

ORGANIC LASER CONFERENCE N65-15502  
TR-64-052.6

GROWTH OF HIGH OPTICAL QUALITY LANTHANUM-ALUMINUM  
OXIDE SINGLE CRYSTAL BY CZOCHRALSKI METHOD -  
DEFENDER PROJECT N65-34084  
SRCR-65-4

DEFENSE  
COMMUNIST CHINA RESEARCH ON LIQUID, SOLID, GAS,  
PLASTIC, GLASS, AND INJECTION LASERS -  
APPLICATIONS IN MEDICINE, INDUSTRY, AND DEFENSE  
JPRS-33257 N66-14355

DEFLECTION  
LARGE ANGLE DEFLECTION TECHNIQUE FOR PRODUCING

# DEFLECTOR

# SUBJECT INDEX

945-LINE TELEVISION TYPE RASTER SCAN IN DISPLAY  
SYSTEM - ELECTRO-OPTICS, LASERS, AND FIBER  
OPTICS  
U1-912008-1 N66-14858

## DEFLECTOR

SYSTEM FOR OPTICAL ACQUISITION AND TRACKING, AND  
LASER BEAM DEFLECTOR DEVICES - ELECTRO-OPTICAL  
TECHNIQUES FOR CONTROLLING DIRECTION OF LASER  
BEAM FLOW  
NASA-CR-64222 N65-30541

## DELAY LINE

LASER OSCILLATION FREQUENCY AND AMPLITUDE  
FLUCTUATIONS MEASURED BY DELAY LINE AND SQUARE LAW  
DETECTOR A65-20510

## DENSITY MEASUREMENT

GAS LASERS - LEVEL POPULATION DEPENDENCES, LASER  
POWER OUTPUT, METASTABLE DENSITY MEASUREMENTS,  
AND PARAMETER CHANGE EFFECT ON MATHEMATICAL  
MODEL OF LASER SYSTEM  
S-740 N65-20002

GAS LASER INTERFEROMETERS FOR PLASMA LOW ELECTRON  
DENSITY MEASUREMENT A66-10856

INSTRUMENTATION TECHNIQUES FOR NEW TYPE OF GAS  
DENSITY MEASURING SYSTEM USING LIGHT SCATTERED  
FROM LASER BEAM AS MEASURED QUANTITY A66-15794

## DETECTION

OPTICAL HETERODYNE DETECTION OF MICROWAVE  
MODULATED LIGHT USING TWO SEPARATE LASERS  
EDL-M779 N65-16777

GIANT RADIO TELESCOPE TO DETECT EXTRATERRESTRIAL  
RADIATION, RAMAN SCATTERING LASERS, FORECASTING  
SOLAR FLARES FOR MANNED SPACE FLIGHT, VOSKHOD  
II LIFE SUPPORT, AND ALUMINUM NITRIDE FILMS  
N65-32675

## DETECTOR

OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER  
AS TRANSMITTER AND SILICON P-I-N PHOTODIODE AS  
DETECTOR USED AS AIRCRAFT ALTIMETER N66-11665

IMPROVED QUANTUM EFFICIENCY FROM LIGHT TRAPPED IN  
TRANSLUCENT PHOTOCATHODE LASER DETECTORS  
ITIL-66-1002 N66-20166

## DETONATION WAVE

ONSET OF RETONATION, LASER TECHNOLOGY AND HIGH  
REPETITION-HIGH RESOLUTION SCHLIEREN STROBOSCOPIC  
WAVE PHENOMENA RECORDS A66-19200

## DIELECTRIC CONSTANT

MULTIMODE LASER OSCILLATION RESULTING FROM  
MODULATION OF DIELECTRIC CONSTANT AND OF LOSS OR  
GAIN OF LASER MEDIUM A65-17652

MODE GUIDING AND GAIN IN JUNCTION LASER DUE TO  
DIELECTRIC SANDWICH CONFINING WAVE PROPAGATION  
A66-13952

PARASITIC INTERNAL OSCILLATIONS IN LASER CRYSTAL  
WITH DIELECTRIC ROD CAUSED BY TOTAL REFLECTION  
FROM GENERATRIX OF CYLINDRICAL SAMPLE A66-22739

## DIELECTRIC MATERIAL

TRANSMISSION OF HIGH-POWER LASER LIGHT FOR  
DIELECTRIC TUBES AND RODS A65-29164

LOW-LOSS MULTILAYER DIELECTRIC COATINGS BY FILM  
DEPOSITION FOR LASER MIRROR A65-29525

OPTICAL COHERENCE AND NONLINEAR INTERACTION OF  
LIGHT WAVES IN DIELECTRICS  
REPT.-1579-17 N65-21553

IONIZATION UNDER LASER ACTION EXTENDED TO METALS  
AND DIELECTRICS, NOTING INFLUENCE ON THRESHOLDS  
A66-17065

## DIELECTRIC POLARIZATION

DIRECT CURRENT POLARIZATION IN NONLINEAR

DIELECTRIC MEDIUM AT OPTICAL FREQUENCY  
TR-EE-64-5 N65-22518

## DIELECTRICS

SECOND HARMONIC LIGHT GENERATION IN CADMIUM  
SULFIDE CRYSTAL NEAR ABSORPTION BAND A65-31220

## DIFFERENTIAL EQUATION

OSCILLATORY BEHAVIOR OF NEODYMIUM DOPED CALCIUM  
TUNGSTATE SOLID STATE LASERS WITH CW EMISSION  
BASED ON RATE EQUATIONS A65-19998

RELAXATION OSCILLATIONS IN FOUR-LEVEL SOLID STATE  
LASER STUDIED VIA DIFFERENTIAL EQUATIONS,  
CALCULATING SHAPE AND ENVELOPE OF OSCILLATION  
A65-30574

## DIFFRACTION GRATING

POLARIZATION EFFECT ON ENERGY DISTRIBUTION AND  
EFFICIENCY IN DIFFRACTION GRATING OF ATTENUATED  
LASER LIGHT A65-16581

LIGHT DIFFRACTION BY GRATING DUE TO FARADAY AND  
KERR EFFECT IN ELECTROMAGNETIC FIELD OF LASER  
BEAM A65-26582

REFLECTION GRATINGS AS END PLATES IN FABRY-  
PEROT CAVITY, WITH CHARACTERISTICS OF LOW  
ABSORPTION OUTPUT COUPLING AND WAVELENGTH-  
DEPENDENT ALIGNMENT OF END PLATES A66-19930

OPTICAL DIFFRACTION VELOCIMETER, USING  
BACKSCATTERED LASER LIGHT TO MEASURE RELATIVE  
VELOCITY BETWEEN LIGHT SOURCE AND SURFACE  
A66-22958

LASER ACTION ON ROTATIONAL LINE IN CARBON DIOXIDE  
AND NITROUS OXIDE VIBRATIONAL SPECTRA IN BOTH P  
AND R BRANCHES UP TO J VALUES OF OVER 50  
A66-23357

## DIFFRACTION PATTERN

MODE IMPURITY OBSERVED IN DIFFRACTION MEASUREMENTS  
EMPLOYING GAS LASER APPARENTLY RESONATING IN  
TEM-00 MODE A65-16571

LASER FOG DISDRUMETER FOR MEASURING DROPLET SIZE  
IN FOG A65-17644

RUBY LASER FIELD PATTERNS - DIFFRACTION PATTERNS  
TR-1 N65-22896

MAXWELL EQUATIONS AS MATHEMATICAL MODELS FOR  
SOLUTION OF DIFFRACTION IMAGING THEORY OF  
COHERENT MONOCHROMATIC LIGHT IN MICROSCOPY  
N65-23494

LASER WITH DIFFRACTION LIMITED RADIATION PATTERN  
A66-10450

LASER WITH DIFFRACTION LIMITED RADIATION PATTERN  
A66-13313

## DIFFRACTION PROPAGATION

DIFFRACTION LOSSES, PHASE SHIFTS AND FIELD  
DISTRIBUTION FUNCTIONS FOR TWO LOWEST-ORDER MODES  
ON INTERFEROMETER-TYPE MASER RESONATORS WITH  
CIRCULAR MIRRORS A65-24911

EFFICIENT DIFFRACTION OF INCIDENT LASER BEAM AT  
BRAGG ANGLE INCIDENCE INTO FIRST-ORDER MODE,  
USING TRAVELING ULTRASONIC WAVES IN WATER  
A65-33057

DIFFRACTION VELOCIMETER DETECTING AND MEASURING  
TRANSVERSE MOVEMENT OF SURFACE BY SENSING LIGHT  
BACKSCATTERED BY IT WHEN LASER ILLUMINATED  
A66-18333

## DIFFRACTOMETER

CONTINUOUS OUTPUT GAS-PHASE LASERS AS SMALL  
BANDWIDTH SOURCES OF LIGHT FOR OPTICAL  
DIFFRACTOMETERS A65-22206

## DIFFUSION

SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION,  
CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION,

# SUBJECT INDEX

# DISTRIBUTION FUNCTION

- FREQUENCY MODULATION LASERS, AND GALLIUM COMPOUND INGOTS FOR LASER APPLICATION  
AFCRL-64-1007 N65-23135
- ZINC DIFFUSION IN GALLIUM ARSENIDE-PHOSPHIDE LASERS AND EFFECTS ON SEMICONDUCTOR JUNCTIONS  
AFCRL-66-18 N66-22611
- DIFFUSION COEFFICIENT**  
HOMOGENEITY AND DIFFUSION LENGTH OF MINORITY CARRIERS IN SEMICONDUCTORS MEASURED, USING LASER BEAM A65-33809
- RUBY LASER PULSE TECHNIQUE APPLIED TO THERMAL DIFFUSIVITY MEASUREMENTS FOR TANTALUM AND GRAPHITE  
CONF-651020-1 N66-18228
- DIMETHYL FORMAMIDE**  
EMISSION SPECTRA OF TRIS AND TETRAKIS FORMS OF FOUR BETA-DIKETONE EUROPIUM CHELATES STUDIED FOR LIQUID LASER APPLICATION A65-33308
- DIODE**  
SWITCHING CHARACTERISTICS OF NEGATIVE RESISTANCE DIODE DETERMINATION - INJECTION LASER REPT.-7 N65-27203
- EXTERNAL POWER EFFICIENCY OF GALLIUM ARSENIDE LASER DIODES  
QPR-2 N65-32069
- STORAGE DIODE LASER RESEARCH  
AD-618297 N65-34108
- HIGH POWER GALLIUM-ARSENIC INJECTION LASER DIODES  
AD-621649 N66-13744
- ROOM TEMPERATURE OPERATION OF PULSED GALLIUM ARSENIDE INJECTION LASER, AND IMPROVEMENT OF LASER DIODE STRUCTURE  
ECOM-01501-1 N66-20809
- SEMICONDUCTOR INJECTION LASER FOR CONTINUOUS OPERATION AT ROOM TEMPERATURE IN VISIBLE WAVELENGTH RANGE  
NASA-CR-74018 N66-23746
- DIRECT CURRENT /DC/**  
DIRECT CURRENT POLARIZATION IN NONLINEAR DIELECTRIC MEDIUM AT OPTICAL FREQUENCY  
TR-EE-64-5 N65-22518
- TWO TYPES OF NONLINEAR INTERACTION OF INTENSE LASER BEAM WITH DIELECTRIC MEDIUM - NONLINEAR DC POLARIZATION AND SUBHARMONICS GENERATION AT OPTICAL FREQUENCIES  
AD-618473 N65-33899
- DISCHARGE**  
ELECTRON ENERGY SPECTRA IN GAS LASER DISCHARGES AND INVESTIGATION OF NEW DISCHARGE CONFIGURATIONS  
NASA-CR-67298 N65-35355
- DISCHARGE TUBE**  
GAS LASER CONTINUOUS WAVE AMPLIFIER USING RECTANGULAR CROSS SECTION DISCHARGE TUBE, NOTING OPERATION AS CW OSCILLATOR AND PULSE AMPLIFIER  
A65-16406
- OPTICAL RESONATOR EFFECTS ON POPULATION DISTRIBUTION IN HELIUM-NEON GAS LASERS DETERMINED FROM SIDE LIGHT MEASUREMENTS  
A65-21656
- GAS MIXTURES AND PRESSURES FOR OPTIMUM OUTPUT POWER OF RF-EXCITED HELIUM-NEON GAS LASERS AT 632.8 NM  
A65-22620
- HELIUM-NEON LASER MULTIBEAM GENERATION IN GAS DISCHARGE TUBE, USING SPHERICAL MIRRORS AND TAPERED PLATES  
A65-24824
- GAS CONSTITUTION OF HELIUM-NEON LASER DISCHARGE ANALYZED, CONSIDERING SPECTRUM LINE RELATIVE INTENSITIES IN LIGHT EMITTED FROM DISCHARGE TUBE  
A65-30333
- TIME RESOLVED SPECTROSCOPY OF MERCURY-HELIUM
- DISCHARGE AND 6150 ANGSTROM LASER OSCILLATION, EXAMINING METASTABLE ATOM STATE  
A65-33518
- OPTICAL PROPERTIES OF CHANGES IN GAS COMPOSITION IN DISCHARGE TUBE FOR HELIUM NEON LASER  
TR-64-257.10 N65-19952
- CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF HF DISCHARGE IN HELIUM-NEON LASER  
A66-10704
- CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF HF DISCHARGE IN HELIUM-NEON LASER  
A66-23309
- ARC TUBE CONSTRUCTED FOR COOLING ARGON ION LASER - DISCHARGE TUBE  
GE/EE/65-1 N66-14188
- DISCRIMINATOR**  
OPTICAL DISCRIMINATOR SYSTEM TO IDENTIFY INFRARED REFLECTING SURFACES FOR USE IN MASER RESEARCH  
MDL-TM-65-41 N66-17361
- DISPERSION**  
HELIUM-NEON LASER RADIATION DISPERSION MEASUREMENT IN TRANSITION 3S2-2P4 FOR VARYING MIRROR SPACING  
A65-19693
- DISPERSION OF 1.15 MICRON HE- NE LASER LINE RESULTING FROM NEON ABSORPTION TRANSITION  
A65-31762
- EFFECT OF OPTICAL PUMPING ON ANOMALOUS DISPERSION IN SELECTED RUBY LASERS AND VARIATION OF REFRACTIVE INDEX DURING LASER OPERATION  
SATR-3 N65-28619
- SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION PROPERTY CHANGES DUE TO PULSED RUBY LASER RADIATION  
A66-15354
- SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION PROPERTY CHANGES DUE TO PULSED RUBY LASER RADIATION  
A66-20895
- DISPLAY SYSTEM**  
USE OF OPTICAL MASERS IN DISPLAYS AND PRINTERS - DIGITAL ELECTRO-OPTIC LIGHT DEFLECTOR, CEMENTING OF CALCITE CRYSTALS, HIGH SPEED ELECTRONIC SWITCHES, AND BIREFRINGENT CRYSTALS  
REPT.-6 N65-13857
- REAL TIME, PROJECTION DISPLAY SYSTEM USING LASER LIGHT SOURCE  
UL-903600-1 N65-35989
- LARGE ANGLE DEFLECTION TECHNIQUE FOR PRODUCING 945-LINE TELEVISION TYPE RASTER SCAN IN DISPLAY SYSTEM - ELECTRO-OPTICS, LASERS, AND FIBER OPTICS  
UL-912008-1 N66-14858
- LARGE-ANGLE DEFLECTION METHOD FOR PRODUCTION OF TV TYPE RASTER SCAN IN LASER DISPLAY SYSTEM  
U2-912008-2 N66-22498
- DISTANCE MEASURING EQUIPMENT**  
EARTH- MOON DISTANCE MEASUREMENT USING LASER TECHNIQUE  
A66-20129
- DISTILLATION APPARATUS**  
RESEARCH IN CHINESE PEOPLES REPUBLIC - SOLAR FLUX, GAS DISCHARGE TUBE, NEODYMIUM LASER, GEOLOGICAL MECHANICS, MICROCRYSTALLINE GLASS, LOCATING OF THUNDER, AND PURIFICATION WITH DISTILLATION METHODS  
JPRS-33759 N66-16806
- DISTRIBUTION FUNCTION**  
RELATION BETWEEN QUANTUM AND SEMICLASSICAL DESCRIPTION OF OPTICAL COHERENCE, CONSIDERING DISTRIBUTION FUNCTION  
A65-21379
- NONLINEAR THEORY OF LASER NOISE WITH CORRELATION FUNCTIONS DERIVED FROM DISTRIBUTION FUNCTIONS OBTAINED BY FOKKER- PLANCK EQUATION  
A65-27759



CORRELATION FUNCTIONS OF AMPLITUDE AND INTENSITY FLUCTUATION FOR LASER MODEL NEAR THRESHOLD OBTAINED BY USING DISTRIBUTION FUNCTIONS EVALUATED BY FOKKER-PLANCK EQUATION, TREATING AMPLITUDE AS RANDOM VARIABLE A66-25018

## DOPING

INJECTION DIODE LASER FROM DEGENERATED GALLIUM ARSENIDE WITH NEODYMIUM DOPED LAYER EMITTING AT 8700 ANGSTROMS A65-15995

CRYSTAL GROWTH AND PREPARATION OF POTENTIAL LASER MATERIAL CONTAINING RARE EARTH IONS AS DOPANTS A65-17042

LASER EMISSION FROM N TYPE GALLIUM ARSENIDE CRYSTAL BY FAST ELECTRON EXCITATION, NOTING DOPING AND EMISSION ENERGY A65-19546

OPTIMIZING FLASH LAMPS FOR PUMPING LASER RODS BY MEANS OF DOPING AD-613346 N65-25890

LINE WIDTH AND INVERSION RATIOS OF IRON-DOPED RUTILE FOR OPTICAL MASER APPLICATIONS NASA-TM-X-54754 N65-29390

## DOPPLER EFFECT

LOCKING OF MODES IN HE-NE LASER AT 6328 ANGSTROMS, USING EXTERNAL DOPPLER CELL A65-16668

GASEOUS OPTICAL MASERS CONSIDERING PROBLEM OF DOPPLER BROADENED TRANSITION SUBJECTED TO OPTICAL FREQUENCY FIELD IN STANDING WAVE FORM A65-24005

LASER DOPPLER FLOWMETER MEASUREMENT TECHNIQUE FOR LOCALIZED FLOW VELOCITIES IN GAS, NOTING RELIABILITY FOR HIGH FLOW VELOCITIES A65-35061

LASER FLOW METER FOR MEASUREMENT OF LOCAL VELOCITY IN CONTAMINATED GAS FLOW FIELDS - DOPPLER SHIFT TECHNIQUE R-149 N65-26015

OPTICAL SUPERHETERODYNE RECEIVER - LASER SYSTEM, DOPPLER FREQUENCY TRACKING, AND OPTICAL TRACKING NASA-CR-63393 N65-26401

CONTINUOUS WAVE GAS LASER DOPPLER FLOW METER FOR GAS VELOCITY MEASUREMENT N66-22338

## DOPPLER RADAR

MOTION SENSING BY OPTICAL HETERODYNE DOPPLER DETECTION FROM DIFFUSE SURFACES, EXAMINING SPATIAL COHERENCY OF SIGNAL A65-19628

NARROW BAND LASER DOPPLER RADAR NAVIGATION INSTRUMENT FOR INSTANTANEOUS GROUND SPEED TRG-019-1-1 N65-27932

DOPPLER OPTICAL NAVIGATOR TO MEASURE INSTANTANEOUS GROUND SPEED WITH 0.1 FT/SEC ACCURACY FOR ALTITUDES OF 250 TO 5000 FEET - CONTINUOUS WAVE LASER AS TRANSMITTER TRG-019-1-2 N65-28160

CLEAR AIR TURBULENCE DETECTION WITH LASER DOPPLER OPTICAL RADAR AIAA PAPER 66-374 A66-24498

## DOSIMETER

PULSED LASER DOSIMETER THAT MEASURES DANGER LEVEL OF RADIATION OF DIRECT OR REFLECTED BEAMS AS SAFEGUARD TO EYE DAMAGE A65-21951

## DRILL

LASER BEAM MACHINING AND DRILLING TECHNIQUES FOR USE ON ANY MATERIAL REGARDLESS OF THERMAL PROPERTIES A65-25373

## DROP SIZE

LASER FOG DISDROMETER FOR MEASURING DROPLET SIZE IN FOG A65-17644

## DUPLEXER

ELECTRONIC DEVICES - DUPLEXERS, PLASMA AMPLIFIERS, CATHODE RAY TUBES, CAPACITORS, THIN FILM TECHNIQUES, AND OPTICAL MASERS SR-85 N65-33773

## DYE

RUBY LASER Q-SWITCHING USING PASSIVE SOLID STATE OR LIQUID ORGANIC BLUE DYE TD-8-64-15 N65-22933

## DYNAMICS

DYNAMIC STRESS CONCENTRATION USING PHOTOELASTICITY AND RUBY LASER LIGHT SOURCE TEAM-285 N66-20850

## DYSPROSIUM

FABRICATION AND TEST OF CONTINUOUS WAVE LASER ACTION FROM DYSPROSIUM IN CALCIUM FLUORIDE EXCITED BY TUNGSTEN LAMP A65-19184

LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM ION IN VARIOUS CONCENTRATIONS A65-24881

LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM ION IN VARIOUS CONCENTRATIONS A65-36358

DYSPROSIUM DOPED CALCIUM FLUORIDE DOPED LASER, USING SOLAR RADIATION FOR EXCITATION AND OPERATING AT 77 DEGREES K A65-36361

RUBY LASER RADIATION EFFECT ON FLUORESCENCE AND LASER ACTION IN DYSPROSIUM DOPED CALCIUM FLUORIDE CRYSTALS A66-10718

## E

## EARTH ATMOSPHERE

EARTH ATMOSPHERE PROPERTIES INVESTIGATION BASED ON LASER BEAM BACKSCATTERING MEASUREMENTS NASA-CR-70177 N66-16967

## EARTH-MOON SYSTEM

EARTH-MOON DISTANCE MEASUREMENT USING LASER TECHNIQUE A66-20129

## EIGENVALUE

INTEGRAL EQUATIONS GOVERNING MODE SPECTRA OF LASER, INVESTIGATING EXISTENCE OF EIGENVALUES FOR HOLDER CONTINUOUS KERNELS A65-15806

EIGENVALUES OF INTEGRAL EQUATIONS IN LASER RESONANT CAVITIES A66-21343

## EIGENVECTOR

TWO-LEVEL ATOM INTERACTION WITH MULTIMODE GAS LASER CAVITY, OBTAINING STATIONARY STATE AND SOLVING UNIQUE EIGENVALUE IN SPECIAL CASES A66-24568

## ELASTIC WAVE

LASER EXCITATION IN QUARTZ OF ELASTIC MODES OF THICK PLATE, SUGGESTING ENERGY COUPLING MECHANISMS A66-12423

## ELECTRIC ANALOGY

ELECTRIC CIRCUIT ANALOG OPTIMUM DESIGN OF MODE-SELECTIVE MULTIREFLECTOR FABRY-PEROT LASER RESONATORS A65-30344

## ELECTRIC BREAKDOWN

IONIZATION BREAKDOWN MECHANISMS OF GASES AT OPTICAL INFRARED FREQUENCIES USING LASERS RAD-COR-64-422 N65-18624

ATMOSPHERIC BREAKDOWN LIMITATIONS TO OPTICAL MASER PROPAGATION A66-14837

GAS BREAKDOWN BY LASER CAN BE ACCOUNTED FOR BY BOTH MICROWAVE BREAKDOWN THEORY AND INVERSE BREMSSTRAHLUNG A66-17040

MECHANISMS ASSOCIATED WITH ELECTRICAL BREAKDOWN AND IONIZATION IN GAS CAUSED BY HIGH INTENSITY RUBY OR NEODYMIUM LASER ILLUMINATION C-920272-4 N66-11453

# SUBJECT INDEX

# ELECTROMAGNETIC FIELD

## ELECTRIC DISCHARGE

OPTIMUM LASER EMISSION MODES RESULTING FROM HOLLOW CATHODE TUBE DISCHARGE DUE TO INELASTIC HELIUM NEON ATOM COLLISIONS A65-18556

HELIUM-NEON LASER OUTPUT DEPENDENCE ON HOLLOW CATHODE DISCHARGE CONDITIONS FOR ELECTRON TRANSITIONS IN NEON A65-25591

OPTIMUM LASER EMISSION MODES RESULTING FROM HOLLOW CATHODE TUBE DISCHARGE DUE TO INELASTIC HELIUM NEON ATOM COLLISIONS A65-27149

LASER OSCILLATIONS FROM PULSED ELECTRICAL DISCHARGE THROUGH NITROUS OXIDE AT 10.9 MICRON WAVELENGTH N65-20172

LASER OSCILLATIONS AT WAVELENGTHS BETWEEN 21 AND 32 MICRONS FROM PULSED DISCHARGE THROUGH AMMONIA N65-20173

HELIUM-NEON LASER OUTPUT DEPENDENCE ON HOLLOW CATHODE DISCHARGE CONDITIONS FOR ELECTRON TRANSITIONS IN NEON A66-11422

EXCITATION OF RUBY LASERS USING DOUBLE-PUMPED HIGH-INTENSITY HELICAL FLASH TUBES, OBTAINING TIME-RESOLVED SPECTRA OF ELECTRICAL DISCHARGES AND PLASMA TEMPERATURES A66-11446

## ELECTRIC FIELD

SPATIAL DISTRIBUTION OF ELECTRICAL FIELD OBTAINED BY FOCUSING RADIATION OF RUBY LASER A66-10250

## ELECTRIC FIELD STRENGTH

NONLINEAR OPTICAL EFFECTS IN CRYSTALLINE AND ISOTROPIC MATERIALS DUE TO INDUCED POLARIZATION THIRD ORDER IN ELECTRIC FIELD STRENGTH, USING GIANT PULSED LASER SOURCE A65-16863

HYDROGEN MOLECULE MULTIPHOTON IONIZATION, DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY RUBY LASER EMISSION A66-16517

HYDROGEN MOLECULE MULTIPHOTON IONIZATION, DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY RUBY LASER EMISSION A66-20898

## ELECTRIC POWER CONVERSION

THERMONUCLEAR FUSION CONTROL FOR ELECTRIC POWER CONVERSION - THETA PINCH, ION CYCLOTRON, AND INFRARED MASER DIAGNOSTICS N65-24859

## ELECTRIC PROPULSION

PRODUCTION OF ION VELOCITIES OVER 4 KM/SEC BY FOCUSED RUBY LASER MAKES PRACTICAL APPLICATION IN DIRECT THRUSTORS AND AS PLASMA SOURCE IN ACCELERATOR TYPE THRUSTORS A65-23626

## ELECTRO-OPTICS

SYSTEM TRANSLATING FREQUENCY OF GAS LASER OVER RANGE OF SEVERAL GIGACYCLES, ELIMINATING NEED FOR ELECTRO-OPTIC CRYSTALS WITH CUBIC SYMMETRY A65-25872

SATELLITE-BORNE LASER ELECTRO-OPTICAL NAVIGATION SYSTEM, ANALYZING ANGULAR TRACKER AND CORNER-REFLECTOR SENSOR A65-29242

LASER IN SPACE APPLICATION, DISCUSSING ELECTRO-OPTICAL DEVICES A65-31883

SYSTEM FOR OPTICAL ACQUISITION AND TRACKING, AND LASER BEAM DEFLECTOR DEVICES - ELECTRO-OPTICAL TECHNIQUES FOR CONTROLLING DIRECTION OF LASER BEAM FLOW NASA-CR-64222 N65-30541

OPTICAL RECTIFICATION IN CRYSTALS USING RUBY LASER BEAM TID-21807 N65-35445

STATIC CHARACTERISTICS OF GAS LASER INTERNAL MODULATION CIRCUIT, USING ELECTRO-OPTICAL CRYSTAL INSERTED INTO GAS LASER RESONATOR A66-14059

LARGE ANGLE DEFLECTION TECHNIQUE FOR PRODUCING

945-LINE TELEVISION TYPE RASTER SCAN IN DISPLAY SYSTEM - ELECTRO-OPTICS, LASERS, AND FIBER OPTICS UI-912008-1 N66-14858

EXCITED STATE SATURABLE ABSORBER USED WITH 1.06 MICRON NEODYMIUM GLASS LASER RADOC-TR-65-369 N66-15701

PIEZOELECTRICALLY POWERED LASER BEAM WAVEGUIDE FOR ELECTRO-OPTICAL ACQUISITION AND TRACKING NASA-CR-68895 N66-17291

ELECTRO-OPTICS CONTRIBUTIONS TO OPTICAL ASTRONOMY, IMAGE TRANSDUCERS, AND LASER RESEARCH AND EFFECT ON CIVILIAN TECHNOLOGY N66-17721

EXPERIMENTAL AND THEORETICAL PROGRAM TO DETERMINE FUNDAMENTAL PROPERTIES OF FREQUENCY MODULATION AND SUPER-MODE LASERS IER-2 N66-21405

## ELECTROACOUSTIC WAVE

HYPERSONIC WAVE GENERATION BY SUPERPOSITION OF TWO COHERENT LIGHT BEAMS IN SOLID OR LIQUID DIELECTRIC A65-15880

## ELECTROCHEMISTRY

RESEARCH REPORTS ON CODER COMPONENTS, POLYMERS, SPECTROSCOPY, LASERS, ELECTROCHEMISTRY, TRANSMISSION LINES, AND SEMICONDUCTOR PHYSICS NAVNEPS-8150 N65-15565

STUDIES ON RADIATION PROTECTION FOR MAN, OPTICAL MASER OF NEODYMIUM IN TUNGSTATE, CYLINDER WAVE PROPAGATION ANALYSIS, AND ELECTROMOTIVE FORCE OF INDIUM ANTIMONIDE COMPOUND JPRS-33152 N66-15042

## ELECTROLUMINESCENCE

FORWARD BIASED P-N JUNCTION ELECTROLUMINESCENCE THEORY AND APPLICATIONS TO DIODE LASERS A65-18872

ELECTROLUMINESCENCE OF ZINC DIFFUSED DIODES IN FORWARD AND REVERSE BIAS, OBSERVING EMISSION SPECTRA AND LASING ACTION IN NEAR-EDGE LINE A65-21617

INDIUM ARSENIDE DIODE SPONTANEOUS AND LASER ELECTROLUMINESCENCE IN MAGNETIC FIELDS A65-24961

IMPROVEMENT OF P-N JUNCTION IN GALLIUM ARSENIDE BY INCREASING QUANTUM EFFICIENCY FOR DIRECT CURRENT STIMULATED ELECTROLUMINESCENCE - LASERS AD-461889 N65-26930

LIGHT EMISSION IN FORWARD BIASED SEMICONDUCTOR P-N JUNCTION A66-12577

## ELECTROMAGNETIC FIELD

OPTICAL MASER THEORY INCLUDING OSCILLATORS, RADIATION EMISSION, QUANTUM MECHANICS, ETC A65-24004

INTEGRAL REPRESENTATION FOR ELECTROMAGNETIC FIELD IN FOCAL REGION OF COHERENT LIGHT BEAM EMERGING FROM APLANATIC OPTICAL SYSTEM A65-27092

MODEL FOR BEHAVIOR OF OPTICAL MASER IN STATIC MAGNETIC FIELD OF ARBITRARY STRENGTH IN Z DIRECTION AND IN ELECTROMAGNETIC FIELD COMPOSED OF TRAVELING WAVES A66-13135

DERIVATION OF TWO EQUATIONS FOR ELECTROMAGNETIC FIELD AND POPULATION INVERSION IN SOLID STATE LASER A66-16773

PLASMA RESEARCH - SOLIDS, LIQUIDS, HEATING AND ACCELERATION BY HIGH AMPLITUDE ELECTROMAGNETIC FIELDS, LASER PRODUCED, ELECTRON HEATING AND REFLECTION, AND OPTICAL INTERACTIONS N66-10960

MILLIMETER AND SUBMILLIMETER MASER DEVICES - IRON-COPEO MASER AMPLIFIER, PUSH-PULL RUTILE MASER, AND X-BAND ZERO FIELD MASERS REPT.-490H N66-16210

## ELECTROMAGNETIC INTERACTION

## SUBJECT INDEX

## ELECTROMAGNETIC INTERACTION

INTERACTION BETWEEN OPTICAL MASER MEDIUM AND  
ELECTROMAGNETIC PULSE PROPAGATING IN IT,  
DISCUSSING AMPLIFIER EQUATIONS AND STEADY STATE  
PULSE / SSP/ IN AND OUT OF RESONANCE

A65-33374

## ELECTROMAGNETIC RADIATION

COHERENT LASER BEAM USED TO SHOW CONSTANCY OF  
VELOCITY OF ELECTROMAGNETIC RADIATION

A65-14215

MASERS AND LASERS, DISCUSSING COHERENT RADIATION  
BY ATOMS AND MOLECULES AND QUANTUM ELECTRONICS  
TECHNIQUES OF GENERATING ACOUSTIC OR  
ELECTROMAGNETIC SPECTRUM

A65-31383

LASER BEAM USE IN BIOLOGY AND MEDICINE, NOTING  
INTERACTION OF ELECTROMAGNETIC RADIATION WITH  
BIOLOGICAL SYSTEMS, HAZARDS, DIAGNOSTICS,  
THERAPEUTICS, ETC

A66-14455

OPTICAL MASER AS POWER SOURCE FOR NARROW BAND  
ELECTROMAGNETIC RADIATION THROUGH STIMULATED  
RAMAN SCATTERING - SOLID STATE PHYSICS  
REPT.-1935-6

N66-10581

## ELECTROMAGNETIC SCATTERING

THOMSON SCATTERING SPECTRUM OF LASER BEAM FROM  
EQUILIBRIUM HYDROGEN PLASMA, NOTING EFFECT OF  
DEBYE LENGTH

A65-17151

MAGNETIC FIELD PROBE IN ELECTROMAGNETICALLY DRIVEN  
SHOCK TUBE AND COHERENT LIGHT IN IONIZING SHOCK  
WAVE PLASMA DIAGNOSTICS

A65-29569

RADIATION SCATTERING FROM LASER BEAM BY FREE  
PLASMA ELECTRONS  
NSL-64-168-1

N65-20300

## ELECTROMAGNETIC SHOCK TUBE

THOMSON SCATTERING MEASUREMENTS OF MAGNETIC  
ANNULAR SHOCK TUBE PLASMAS USING Q-SWITCHED RUBY  
LASER LIGHT BEAM

A66-14707

## ELECTROMAGNETIC WAVE

PLANE STATIONARY MODE OF TW LASER AMPLIFIER WITH  
FEEDBACK

A65-19683

ACCURATE LOCATION OF OBJECT IN SPACE AND TIME AND  
CORRECTION OF MOVEMENTS BY USE OF QUANTUM  
ELECTRODYNAMICS

A65-25036

INTERACTION OF ENERGETIC ELECTRONS WITH BOUNDED  
ELECTROMAGNETIC WAVES NEAR CYCLOTRON RESONANCE,  
NOTING PLASMA DIAGNOSTICS, MASER AND GAIN  
MECHANISM

A66-13953

INTENSITY DISTRIBUTION OF FRINGE SYSTEMS USED TO  
VERIFY PHASE INVERSION BETWEEN TWO LOBES OF LASER  
IN TEM-10 MODE

A66-17453

## ELECTROMOTIVE FORCE

STUDIES ON RADIATION PROTECTION FOR MAN, OPTICAL  
MASER OF NEODYMIUM IN TUNGSTATE, CYLINDER WAVE  
PROPAGATION ANALYSIS, AND ELECTROMOTIVE FORCE OF  
INDIUM ANTIMONIDE COMPOUND  
JPRS-33152

N66-15042

## ELECTRON

PLASMA RESEARCH - SOLIDS, LIQUIDS, HEATING AND  
ACCELERATION BY HIGH AMPLITUDE ELECTROMAGNETIC  
FIELDS, LASER PRODUCED, ELECTRON HEATING AND  
REFLECTION, AND OPTICAL INTERACTIONS

N66-10960

## ELECTRON AVALANCHE

PHOTOELECTRONS EMITTED BY PHOTOCATHODE LIT BY HEAT  
SOURCE AND LASER COUNTING NUMBER OF AVALANCHES  
DURING GIVEN TIME

A65-18037

## ELECTRON BEAM

ELECTRON BEAM PENETRATION IN LASER CRYSTALS FROM  
DATA OF KING AND EHRENBURG

A65-22627

NOISE BEHAVIOR OF POTENTIAL MINIMUM OF TRAVELING  
WAVE TUBES AND REDUCTION FACTOR FOR SHOT NOISE  
DETERMINED, USING LASERS

A65-26936

LASER ACTION AT LIQUID HELIUM TEMPERATURE IN  
CRYSTALS OF LEAD SAMARIUM, LEAD SELENIDE AND LEAD  
TELLURIDE EXCITED BY FAST ELECTRON BEAM

A65-30346

TRANSVERSE ELECTRON-BEAM WAVE EXCITATION BY  
PHOTOELECTRIC MIXING OF LASER BEAMS

A65-32874

MICROWAVE PROBLEMS IN ACOUSTIC WAVE INTERACTIONS,  
TRANSVERSE WAVE ELECTRON BEAM, OPTICAL  
SPECTROSCOPY OF LASER MATERIALS, AND NONLINEAR  
QUANTUM STUDIES  
ML-1243

N65-15605

SEMICONDUCTOR LASER WITH ELECTRON BEAM  
AS EXCITATION SOURCE - EMISSION DATA FOR  
VARIOUS BEAM CURRENT DENSITIES

N65-20391

ELECTRON BEAM MELTING HEAT SOURCE IN VACUUM  
METALLURGY, AND RUBY AND NEODYMIUM GLASS LASERS  
FOR INDUSTRY

N65-23723

ELECTRON BEAMS, PLASMA, AND LASERS AND MASERS FOR  
EXTENDING USEFUL FREQUENCY SPECTRUM INTO RANGE  
FROM MICROWAVE TO OPTICAL FREQUENCIES  
MDL-Q12

N65-28149

LASER ACTION BY ELECTRON BEAM PUMPING - LITERATURE  
SURVEY  
NOLTR-65-95

N65-33401

ELECTRON BEAM PUMPING OF NOBLE GAS ION LASER  
A66-10350

FORCED EMISSION FROM ELECTRON-EXCITED CADMIUM  
SELENIDE

A66-22174

ELECTRON BEAM PUMPED LASERS, DISCUSSING ENERGY  
DISSIPATION IN FAST ELECTRONS PASSING THROUGH  
CRYSTAL, LASER SEMICONDUCTOR CHARACTERISTICS, ETC  
A66-23433

SPECTRAL ANALYSIS OF OUTPUT FROM SINGLE CRYSTAL  
SEMICONDUCTOR GENERATOR EXCITED BY ELECTRON  
BEAM - LASERS  
FTD-TT-65-555/1&2&4

N66-12624

RADIATIVE RECOMBINATION WITH ELECTRON BEAM EXCITED  
CADMIUM TELLURIDE AND GALLIUM SELENIDE

N66-12646

ELECTRON BEAM AND HOLLOW CATHODE FLOAT-ZONE  
PROCESSES ANALYSIS FOR APPLICATION TO GROWTH OF  
LASER RUBY CRYSTALS  
AFRL-65-908

N66-21169

## ELECTRON BEAM WELDING

FOCUSED ENERGY TECHNIQUES FOR JOINING, INCLUDING  
LASER WELDING  
ASTME PREPRINT AD66-718

A66-24413

## ELECTRON BOMBARDMENT

ELECTRON BEAM PENETRATION IN LASER CRYSTALS FROM  
DATA OF KING AND EHRENBURG

A65-22627

LASER TRANSITION IDENTIFICATION IN ELECTRON BEAM  
PUMPED GALLIUM ARSENIDE, PRIMARILY ON  
CONCENTRATION OF SHALLOW DONORS AND ACCEPTORS

A66-10348

EXCITATION OF SEMICONDUCTOR LASERS BY BEAM OF FAST  
ELECTRONS, DISCUSSING WORK OF SHOCKLEY, POPOV,  
KELDYSH AND KROKHIN

A66-17337

LASER EMISSION IN PURE CADMIUM SULFIDE CRYSTALS  
BOMBARDED BY ELECTRON BEAMS

A66-18650

## ELECTRON COLLISION

GAS DISCHARGE COLLISION LASER EFFICIENCY AND POWER  
OUTPUT CONSIDERATIONS WITH ATTENTION TO MANGANESE  
AND LANTHANUM DISCHARGES

A65-20062

PULSED MOLECULAR NITROGEN LASER THEORY VIA  
ELECTRON IMPACT EXCITATION OF TRIPLET STATES

A65-33050

## ELECTRON DENSITY

THOMSON SCATTERED LASER RADIATION USED TO

## SUBJECT INDEX

## ELECTRON SPECTRUM

- DETERMINE ELECTRON DENSITY IN HELIUM PLASMA,  
EXAMINING THYRATRON TUBE AND VOLTAGE PROBE USE  
A65-19618
- ELECTRON DENSITY MEASUREMENTS IN PLASMA PRODUCED  
BY COMBINATION OF RF AND VERY FAST THETA-PINCH  
DISCHARGES, USING GAS LASER INTERFEROMETER  
A65-29848
- TIME-DEPENDENT ELECTRON DENSITY VARIATION STUDIED  
IN FAST THETA-PINCH DISCHARGE, USING HE- NE GAS  
LASER INTERFEROMETER  
A65-29849
- LASER INTERFEROMETER TO MEASURE TIME AND SPATIAL  
VARIATION IN REPETITIVELY PULSED PLASMA  
A66-10243
- THOMSON SCATTERING MEASUREMENTS OF MAGNETIC  
ANNULAR SHOCK TUBE PLASMAS USING Q-SWITCHED RUBY  
LASER LIGHT BEAM  
A66-14707
- MEASUREMENT OF ELECTRON DENSITY OF GAS DISCHARGE  
PLASMA BY LASER INTERFEROMETER  
A66-16379
- IONIZATION PHENOMENA IN ARGON DUE TO LASER  
RADIATION BY MEASURING ELECTRON DENSITY AND ENERGY  
AS TIME FUNCTION AFTER LASER PULSE INITIATION AT  
DIFFERENT GAS PRESSURES AND PREIONIZED CONDITIONS  
AIAA PAPER 66-176  
A66-21690
- INFRARED MASER INTERFEROMETRY FOR TIME AND SPACE  
RESOLUTION OF ELECTRON DENSITY IN HIGH  
TEMPERATURE PLASMAS  
ARL-65-135  
N66-20024
- ELECTRON TEMPERATURE AND DENSITY MEASUREMENTS OF  
26 K JOULE THETA-PINCH BY LIGHT SCATTERING  
FROM COMBINED OSCILLATOR-AMPLIFIER LASER  
IPP-1/42  
N66-21141
- ELECTRON EMISSION**  
SINGLE PULSES OF ELECTRON EMISSION PRODUCED BY  
SPINNING-PRISM Q-SWITCHED RUBY LASER  
A65-15443
- BACKGROUND GAS PRESSURE EFFECT ON LASER INDUCED  
ELECTRON EMISSION FROM ZINC AND TANTALUM SURFACES  
A65-15838
- ENERGY MEASUREMENT OF RUBY LASER INDUCED ELECTRON  
EMISSION FROM TUNGSTEN  
A65-20241
- TIME CORRELATION BETWEEN LASER PULSES AND LASER-  
INDUCED ELECTRON EMISSION FROM METALLIC SURFACES  
A65-34616
- TIME RESOLUTION OF ELECTRON AND ION EMISSION  
PRODUCED BY Q-SWITCHED RUBY LASER PULSE FOCUSED  
ON METAL SURFACE  
A66-18358
- THERMOSTIMULATED INDUCED ELECTRON EMISSION FROM  
SAMPLES CUT FROM LASER RUBY CRYSTALS DETECTED WITH  
OPEN POINT COUNTER  
A66-18609
- ELECTRON AND ION EMISSION FROM PULSED RUBY LASER  
ILLUMINATED METALLIC SURFACE INTO VACUUM,  
DETERMINING APPLICATION TO PULSED ION THRUSTOR  
AIAA PAPER 66-230  
A66-21453
- ELECTRON ENERGY**  
INTERACTION OF ENERGETIC ELECTRONS WITH BOUNDED  
ELECTROMAGNETIC WAVES NEAR CYCLOTRON RESONANCE,  
NOTING PLASMA DIAGNOSTICS, MASER AND GAIN  
MECHANISM  
A66-13953
- ELECTRON ENERGY SPECTRA IN NEON, XENON AND HELIUM-  
NEON LASER DISCHARGES, CALCULATING PRODUCTION AND  
DESTRUCTION RATE PARAMETERS  
A66-18354
- ELECTRON IMPACT**  
EXCITATION AND INVERSION METHOD IN GAS LASERS  
NOTING CHARACTERISTICS OF HELIUM-NEON LASER AND  
IONIZED AND THREE-LEVEL LASER SYSTEM  
A66-13951
- GAS DISCHARGE BY LASER PULSE, TAKING INTO ACCOUNT  
PHOTOIONIZATION DUE TO ELECTRON IMPACT  
A66-24887
- ELECTRON IONIZATION**  
CURRENT DISCHARGE OF HELIUM NEON LASER ON LASER  
ACTION  
A66-12439
- ELECTRON MASS**  
EFFECTIVE MASS IN IN AS AND IN SB FROM LANDAU  
SHIFT OF PEAK EMISSION IN LASER DIODES  
A66-21579
- ELECTRON MICROSCOPY**  
REPLICA TECHNIQUES AND ELECTRON AND OPTICAL  
MICROSCOPY TO STUDY LASER IRRADIATED METAL  
SURFACES  
A66-18393
- ELECTRON MULTIPLIER**  
HIGH SENSITIVITY FAST-RESPONSE LASER DETECTION  
SYSTEM, DESCRIBING MICROWAVE RESPONSE  
PHOTOELECTRIC DETECTOR WITH AMPLIFICATION AND  
MIXING FUNCTIONS  
A66-22046
- ELECTRON OPTICS**  
PROCEEDINGS OF INTERNATIONAL SYMPOSIUM ON LASER  
PHYSICS AND APPLICATIONS AT BERN, SWITZERLAND  
IN OCTOBER 1964  
A65-19993
- LASER MODULATOR USING GALLIUM ARSENIDE AND GALLIUM  
PHOSPHIDE ELECTRO-OPTIC CRYSTALS  
NASA-CR-71516  
N66-21435
- ELECTRON PARAMAGNETIC RESONANCE**  
ELECTRON PARAMAGNETIC RESONANCE THEORETICAL  
ASPECTS AND APPLICATION TO ATOMIC NUCLEI  
POLARIZATION, INCREASED SPECTROMETER RESOLUTION  
AND SOLID STATE MASERS  
A65-32773
- LIFE SUPPORT SYSTEM, FLUID AMPLIFICATION,  
SPALLING, COMMUNICATIONS SATELLITE, MICROWAVE  
APPARATUS, HIGH STRENGTH STEEL, TRACERS, LASERS,  
ATMOSPHERIC TURBULENCE, AND RESONANCE  
AD-611432  
N65-22732
- QUANTUM RF PHYSICS TEXT COVERING MAGNETIC  
RESONANCE THEORY, ELECTRON PARAMAGNETIC RESONANCE,  
NUCLEAR MAGNETIC RESONANCES, TWO- AND THREE-LEVEL  
MASERS, RF GAS SPECTROSCOPY AND AMMONIA  
OSCILLATOR  
A66-10954
- OPTICAL ABSORPTION AND ELECTRON PARAMAGNETIC  
RESONANCE TECHNIQUES USED TO STUDY IONIZING  
RADIATION EFFECT ON RUBY LASERS  
NASA-TN-D-3379  
N66-21037
- ELECTRON-PHONON INTERACTION**  
MICROWAVE RESEARCH ON ACOUSTIC WAVE AMPLIFICATIONS  
AND GEOMETRICAL OPTICS, OPTICAL MASERS,  
ELECTRON-PHONON INTERACTIONS, AND RAMAN  
SCATTERING FROM BIREFRINGENT CRYSTALS  
ML-1277  
N65-20038
- ELECTRON PLASMA**  
RADIATION SCATTERING FROM LASER BEAM BY FREE  
PLASMA ELECTRONS  
NSL-64-168-1  
N65-20300
- DIFFUSION OF LIGHT BY PLASMA ELECTRONS PRODUCED IN  
LABORATORY FOR VERY SMALL EFFECTIVE DIFFUSION AREA  
A66-21712
- ELECTRON SCATTERING**  
STIMULATED COMPTON SCATTERING OF ELECTRONS BY  
LASER BEAM  
IS-1187  
N66-20388
- ELECTRON SOURCE**  
LOCAL LASER HEATING OF CATHODE FOR ELECTRON  
EXTRACTION FROM PLASMOID  
A66-16149
- ELECTRON SPECTRUM**  
ELECTRON ENERGY SPECTRA IN GAS LASER DISCHARGES  
AND INVESTIGATION OF NEW DISCHARGE  
CONFIGURATIONS  
NASA-CR-67298  
N65-35355
- ELECTRON ENERGY SPECTRA IN NEON, XENON AND HELIUM-  
NEON LASER DISCHARGES, CALCULATING PRODUCTION AND  
DESTRUCTION RATE PARAMETERS  
A66-18354
- EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING  
SPECTRAL RANGE, DURATION, ELECTRON EXCITATION

## ELECTRON SPIN RESONANCE

## SUBJECT INDEX

MECHANISM AND UPPER WAVELENGTH LIMIT  
A66-19667

EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING  
SPECTRAL RANGE, DURATION, ELECTRON EXCITATION  
MECHANISM AND UPPER WAVELENGTH LIMIT  
A66-21834

**ELECTRON SPIN RESONANCE**  
MAGNITUDE OF ANISOTROPIC LINE BROADENING IN RUBY  
A66-13278

GROUND STATE ESR SATURATION EFFECT ON RUBY LASER  
OUTPUT FREQUENCY AT CRYOGENIC TEMPERATURE  
A66-16753

**ELECTRON STATE**  
LASER OPERATION PRINCIPLES AND OSCILLATING ELEMENT  
OF LASER RESONATOR  
A65-31880

C W LASER ACTION ON TRIPLE STATE PHOSPHORUS-SULFUR  
TRANSITION, USING HYDROGEN SULFIDE-NOBLE GAS  
MIXTURES  
A66-21577

**ELECTRON TEMPERATURE**  
MICROWAVE ELECTRON CYCLOTRON RESONANCE PUMPING OF  
NEON-HELIUM LASER TO RAISE PLASMA ELECTRON  
TEMPERATURE FOR INCREASE OF OUTPUT  
A65-15320

LOCAL ELECTRON TEMPERATURE AND ELECTRON DENSITY IN  
THETA PINCH MEASURED BY MEANS OF SCATTERING OF  
LASER BEAM  
A66-14334

ELECTRON TEMPERATURE AND DENSITY MEASUREMENTS OF  
26 K JOULE THETA-PINCH BY LIGHT SCATTERING  
FROM COMBINED OSCILLATOR-AMPLIFIER LASER  
IPP-1/42  
N66-21141

**ELECTRON TRANSITION**  
TRANSITION PROCESSES OF OSCILLATION AMPLITUDE  
FORMATION IN RF THREE-LEVEL MASERS  
A65-15460

I R LASER ACTION IN ARGON II BETWEEN 1 AND 2  
MICRONS AND IN 6000 TO 7000 ANGSTROM RANGE  
A65-17207

CHEMICAL PROCESSES PRODUCING SPECTROSCOPICALLY  
OBSERVABLE POPULATION INVERSIONS IN ATOMIC OR  
MOLECULAR LASERS  
A65-20066

HELIUM-NEON LASER OUTPUT DEPENDENCE ON HOLLOW  
CATHODE DISCHARGE CONDITIONS FOR ELECTRON  
TRANSITIONS IN NEON  
A65-25591

U V ION LASER TRANSITIONS IN INERT GASES, OXYGEN  
AND NITROGEN BETWEEN 2300 AND 4000 ANGSTROMS,  
SHOWING RELATIONSHIP BETWEEN GAIN AND TUBE  
DIAMETER  
A65-27334

TRANSITION PROCESSES OF OSCILLATION AMPLITUDE  
FORMATION IN RF THREE-LEVEL MASERS  
A65-28556

LASER TRANSITION IDENTIFICATION IN ELECTRON BEAM  
PUMPED GALLIUM ARSENIDE, PRIMARILY ON  
CONCENTRATION OF SHALLOW DONORS AND ACCEPTORS  
A66-10348

LASER ACTION AT 5401 ANGSTROMS IN PURE NEON PULSED  
HIGH VOLTAGE DISCHARGE  
A66-10353

ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION  
INVERSION IN LEVELS OF OPTICAL TRANSITION  
A66-10448

HELIUM-NEON LASER OUTPUT DEPENDENCE ON HOLLOW  
CATHODE DISCHARGE CONDITIONS FOR ELECTRON  
TRANSITIONS IN NEON  
A66-11422

TWO- AND THREE-STEP LASER CASCADES DETECTED  
EXPERIMENTALLY IN HELIUM-NEON MIXTURES, ANALYZING  
TWO-STEP CASCADE STARTING WITH DENSITY MATRIX  
FORMULATION  
A66-11477

ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION  
INVERSION IN LEVELS OF OPTICAL TRANSITION  
A66-13311

**ELECTRON TUBE**  
HYDROGEN MASER AND CESIUM BEAM TUBE FREQUENCY  
STANDARDS COMPARED  
A65-16680

FREQUENCY STANDARDS OF HYDROGEN MASER AND SWISS  
CESIUM ATOMIC BEAM TUBE COMPARED  
A65-16681

**ELECTRONIC EQUIPMENT**  
ELECTRONIC DEVICES - DUPLEXERS, PLASMA AMPLIFIERS,  
CATHODE RAY TUBES, CAPACITORS, THIN FILM  
TECHNIQUES, AND OPTICAL MASERS  
SR-85  
N65-33773

LASER BEAM WELDING ELECTRONIC-COMPONENT LEADS  
A66-14517

ELECTRONICS METHODS USED IN LASER TECHNOLOGY AND  
VICE VERSA, EMPHASIZING MICROWAVE PHOTOELECTRONIC  
DEVICES, SELF-CONSISTENT GAS DISCHARGES AT OPTICAL  
FREQUENCIES, ETC  
A66-20434

**ELECTRONIC LEVEL**  
LASER OSCILLATION IN DECAY OF EXCITED MOLECULES  
FROM CHEMICAL REACTION, NOTING CHANGE IN THREE  
ELECTRONIC LEVELS IN MOLECULAR SYSTEM  
A65-20069

**ELECTRONIC PACKAGING**  
LASER MICROWELDING EVALUATION WITH REGARD TO  
BONDING OF DISSIMILAR ELECTRONIC INTERCONNECTION  
MATERIALS FOR THIN FILM CIRCUITS  
A65-24352

LASER WELDING FOR PRODUCTION MICROWELDING, NOTING  
DESIGN, CONSTRUCTION AND APPLICATION  
ASTME PREPRINT MM66-707  
A66-24415

**ELECTRONICS**  
PROCEEDINGS OF INTERNATIONAL SYMPOSIUM ON LASER  
PHYSICS AND APPLICATIONS AT BERN, SWITZERLAND  
IN OCTOBER 1964  
A65-19993

NINETEENTH ANNUAL CONVENTION OF ARMED FORCES  
COMMUNICATIONS AND ELECTRONICS ASSOCIATION ON  
LASER TECHNOLOGY AND APPLICATION AT FORT  
MONMOUTH, NEW JERSEY IN JUNE 1965  
A65-31879

ELECTRONICS RESEARCH ON TRAVELING WAVE TUBES,  
RARE EARTH TARGETS FOR NEUTRON GENERATORS,  
AND GAS DISCHARGE AND SEMICONDUCTOR  
INJECTION-TYPE LASERS  
N65-20166

RUBY AND NEODYMIUM GLASS LASERS FOR INDUSTRY -  
ELECTRONICS  
N65-23722

PHYSICAL ELECTRONICS, SOLID STATE PHYSICS, LIQUID  
STATE PHYSICS, INFORMATION SCIENCES, AND LASER  
AND COMMUNICATION THEORY  
LMSC-6-75-65-10  
N65-25125

EVALUATION OF MASER-EQUIPPED WEATHER RADAR SET AND  
AREA PRECIPITATION MEASUREMENT INDICATOR -  
METEOROLOGICAL SENSING DEVICE - ELECTRONICS  
QPR-1  
N66-14191

**ELECTROSTATIC GYROSCOPE**  
INERTIAL SENSORS REVIEWING RING LASER,  
ELECTROSTATIC FLUID SPHERE, MAGNETIC RESONANCE,  
SUPERCONDUCTIVITY GYROSCOPE, RELATIVISTIC ROTATING  
TENSOR, VORTEX RATE AND QUANTUM MECHANICAL EFFECT  
SENSING  
AIAA PAPER 65-401  
A65-29669

**ELECTROSTATIC INSTRUMENT**  
ELECTROSTATIC IMAGE CONVERTER CAMERA USED IN  
PLASMA AND LASER RESEARCH FOR HIGH SPEED WRITING  
A65-32585

**ELECTROSTATICS**  
STATIC CHARACTERISTICS OF GAS LASER INTERNAL  
MODULATION CIRCUIT, USING ELECTRO-OPTICAL CRYSTAL  
INSERTED INTO GAS LASER RESONATOR  
A66-14059

**ELEMENT ABUNDANCE**  
LECTURE MANUSCRIPTS ON HIGH ALTITUDE EXPLOSIONS,  
BIOLOGICAL EXPLORATION OF MARS, MASERS AND

## SUBJECT INDEX

## ENERGY DENSITY

- LASERS, PLANETARY ATMOSPHERES, RELATIVITY  
THEORY, ELEMENT ABUNDANCE, AND SOLAR PARTICLES  
N65-31360
- EMBRYO  
LASER RADIATION EFFECT ON VERTEBRATE EMBRYOS  
N65-16624
- EMISSION  
RELAXATION OSCILLATIONS IN EMISSION OF RUBY LASERS  
UNDER VARIOUS OPERATIONAL CONDITIONS  
T-6-215 N65-24968
- MEASUREMENT OF TEMPERATURE DEPENDENCE OF ENERGY  
LEVELS INVOLVED IN LASER EMISSION  
NASA-CR-64436 N65-32191
- INFLUENCE OF RESONANT CAVITY, XENON LIGHT, AND  
OTHER PARAMETERS ON RUBY LASER EMISSION ENERGY  
OUTPUT  
FTD-TT-64-1339/1626364 N66-11522
- THEORY OF INDUCED AND SPONTANEOUS LASER EMISSION  
FROM ATOMIC LEVEL SYSTEM AND INCIDENT BEAMS OF  
RADIATION  
AFRL-65-505 N66-11992
- SPONTANEOUS EMISSION FROM ATOM INTERACTING WITH  
COHERENT LIGHT WAVE  
AFOSR-65-1000 N66-12043
- LASER THEORY WITH CLASSICAL AND QUANTUM MECHANICAL  
APPROACH TO ABSORPTION AND EMISSION  
R-1743 N66-20857
- EMISSION SPECTRUM  
R SUB 1 RUBY LINE EMISSION AND FREQUENCY  
DEPENDENCE ON TEMPERATURE VARIATION  
A65-15205
- XENON-KRYPTON LASER EMISSION IN 12 WAVELENGTHS  
RANGING FROM 2.03 TO 9 MICRONS WITH EXTERNAL AND  
INNER MIRRORS  
A65-17353
- EMISSION AND ABSORPTION PROFILES FOR RUBY R SUB 1  
LINES SHOW ABSENCE OF SIGNIFICANT STOKES SHIFT  
A65-17664
- EMISSION SPECTRUM OF RUBY LASER WITH EXTERNAL  
SPHERICAL MIRRORS IN NONDAMPING INTENSITY  
FLUCTUATIONS AND QUASI-STEADY GENERATION  
A65-21041
- SPECTROSCOPIC DATA ON ABSORPTION, SPONTANEOUS  
FLUORESCENCE AND STIMULATED EMISSION IN ACTINIDES,  
TRANSITION METAL AND SEMICONDUCTOR LASER MATERIAL  
A65-21168
- ELECTROLUMINESCENCE OF ZINC DIFFUSED DIODES IN  
FORWARD AND REVERSE BIAS, OBSERVING EMISSION  
SPECTRA AND LASING ACTION IN NEAR-EDGE LINE  
A65-21617
- DATA ON LASER MATERIALS REFERENCED TO MAY 1964  
INCLUDING LASER EMISSION LINES AND LASER  
PERFORMANCE PARAMETERS  
A65-22616
- EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE  
OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE  
A65-24084
- PB SE DIODE LASER FABRICATION, PROPERTIES AND  
EMISSION SPECTRUM WITH PEAK AT 8.5 MICRONS  
A65-27602
- EMISSION SPECTRA OF TRIS AND TETRAKIS FORMS OF  
FOUR BETA-DIKETONE EUROPIUM CHELATES STUDIED FOR  
LIQUID LASER APPLICATION  
A65-33308
- RADIATIVE TRANSITION PROCESS IN EMISSION SPECTRUM  
OF GALLIUM ARSENIDE P-N JUNCTION LASER DIODES  
A65-34666
- EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE  
OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE  
A65-34905
- WHITE LIGHT EMISSION WHEN PULSED LASER BEAM  
FOCUSES ON TARGETS IS MAINLY DUE TO TEMPERATURE
- RADIATION  
A65-34957
- HIGH INTENSITY ULTRAVIOLET RADIATION SOURCE TO  
PUMP PHOSPHORS AND LASER MATERIALS WITH  
ABSORPTION BANDS IN PHOSPHOR EMISSION SPECTRUM  
CDRF-173 N65-14365
- MULTIPLE LIGHT FILTER NARROWING EMISSION BANDS OF  
RUBY LASER WITH MULTIPLEX RESONATOR  
A66-12627
- MODES OF EMISSION-VS-TIME SPECTRUM, OPTICAL  
EMISSION SPECTRUM AND SUPERPOSITION SPECTRUM OF  
SHORT CONFOCAL RUBY LASER IN NEAR FIELD  
A66-14290
- GALLIUM ARSENIDE P-N JUNCTION LASER DIODE COVERING  
INJECTION CURRENT DISTRIBUTION, DENSITY AND  
EMISSION SPECTRA VARIATION  
A66-14659
- LASER OSCILLATION IN CALCIUM TUNGSTATE CRYSTALS  
ACTIVATED WITH TRIVALENT PRASEODYMIUM  
A66-14898
- EMISSION SPECTRUM OF RUBY MASER CALCULATED, USING  
DYNAMICS OF TWO-LEVEL SYSTEMS  
A66-16541
- TEMPERATURE DEPENDENCE OF EMISSION SPECTRUM AND  
THRESHOLD CURRENT IN GA AS LASERS  
A66-17333
- ISOTOPE SHIFT, LINEWIDTH AND PRECISE WAVELENGTH OF  
LASER EMISSION IN IONIZED HG  
A66-18035
- EMISSION SPECTROSCOPY AND COORDINATION CHEMISTRY  
OF EUROPIUM CHELATE SOLUTIONS - CHELATE LASERS  
INVESTIGATED FOR EVALUATING POTENTIALITIES OF  
LIQUID LASERS  
TR-65-052-11 N66-14177
- ENERGY  
INFLUENCE OF RESONANT CAVITY, XENON LIGHT, AND  
OTHER PARAMETERS ON RUBY LASER EMISSION ENERGY  
OUTPUT  
FTD-TT-64-1339/1626364 N66-11522
- EFFECT OF RUBY LASER ENERGY ON GAMMA RADIATED  
HUMAN ADENOCARCINOMA CELLS  
SAM-TR-65-41 N66-11874
- ENERGY ABSORPTION  
ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN  
ENERGY ABSORPTION AND POPULATION INVERSION  
A65-36055
- PLASMA GENERATION BY FOCUSING LASER BEAM IN AIR AT  
ATMOSPHERIC PRESSURE AND ROOM TEMPERATURE INDICATE  
CONNECTION WITH LUMINOUS ENERGY ABSORPTION DURING  
BREAKDOWN  
A66-14538
- ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN  
ENERGY ABSORPTION AND POPULATION INVERSION  
A66-15858
- ENERGY CONVERSION  
MODEL FOR LASER AMPLIFIER IN WHICH EXCITED  
ELECTRON DENSITY IN HOST LASER MATERIAL IS  
STIMULATED TO PRODUCE OPTICAL ENERGY  
N65-24343
- EFFICIENT CONVERSION OF ELECTRICAL ENERGY INTO  
LASER RADIATION, USING COAXIAL OPTICAL PUMP  
A66-23479
- N ASA PROGRAM OF ADVANCED SPACE RESEARCH AND  
TECHNOLOGY - PLANETARY EXPLORATION, ENERGY  
CONVERSION, MATERIALS SCIENCE, AND LASERS  
N66-12404
- ENERGY CONVERSION EFFICIENCY  
LASER PUMPING TECHNIQUES - THETA PINCH ENERGY  
TRANSFER EFFICIENCY IN CONVERSION OF ELECTRIC  
ENERGY TO ELECTROMAGNETIC ENERGY  
AFOSR-65-2212 N66-15605
- ENERGY DENSITY  
AXIALLY UNIFORM ENERGY DENSITY IN LASER CAVITY

## ENERGY DISTRIBUTION

OBTAINED, USING BIREFRINGENT SAPPHIRE QUARTER WAVE PLATES, RUBY ROD AND TWO MIRRORS  
A65-16407

## ENERGY DISTRIBUTION

POLARIZATION EFFECT ON ENERGY DISTRIBUTION AND EFFICIENCY IN DIFFRACTION GRATING OF ATTENUATED LASER LIGHT  
A65-16581

LASER BEAM DIVERGENCE AND ENERGY DISTRIBUTION MEASUREMENT, USING WIDE LATITUDE FILM AND THIN CELLULOID MIRROR  
A65-17432

ELECTRON ENERGY SPECTRA IN GAS LASER DISCHARGES AND INVESTIGATION OF NEW DISCHARGE CONFIGURATIONS  
NASA-CR-67298 N65-35355

HEATING PROCESS IN LASER WELDING OF METAL SHEETS, TAKING INTO ACCOUNT ENERGY DISTRIBUTION, HEAT TRANSFER AND FLUX DENSITIES  
A66-15347

## ENERGY EXCHANGE

LASER PHYSICS CONFERENCE - ENERGY EXCHANGE IN SOLIDS AND GASES, NONLINEAR EFFECTS, GAS BREAKDOWN, AND REFRACTIVE INDEX VARIATION  
AD-622507 N66-14573

## ENERGY LEVEL

TRANSITION PROCESSES OF OSCILLATION AMPLITUDE FORMATION IN RF THREE-LEVEL MASERS  
A65-15460

C W LASER OSCILLATION ON P BRANCH ROTATIONAL TRANSITIONS OF VIBRATION BAND OF NITROUS OXIDE  
A65-16671

RUBY LASER THRESHOLD PUMPING AND EMISSION ENERGIES RELATED TO TRANSMISSION COEFFICIENT, ROD DIAMETER AND THRESHOLD LEVEL  
A65-20343

MASER PRINCIPLES, PRACTICAL DESIGN AND CURRENT APPLICATION  
A65-30377

MEASUREMENT OF TEMPERATURE DEPENDENCE OF ENERGY LEVELS INVOLVED IN LASER EMISSION  
NASA-CR-64436 N65-32191

## ENERGY LOSS

OPTIMUM PEAK POWER FROM GIANT PULSE LASER IN TERMS OF LOSS FACTOR AND POPULATION DENSITY  
A65-15824

PULSED RUBY LASER ROD CAVITY LOSS MEASUREMENTS FROM 77 TO 293 DEGREES K INDICATING ESSENTIALLY CONSTANT LOSS  
A65-16129

STIMULATED EMISSION OF ELECTROMAGNETIC WAVES FROM CIRCULAR CYLINDER AND SPHERE  
A65-17219

INTERNAL LOSSES EFFECT ON RADIATION POWER IN LASER  
A65-24058

LASER OSCILLATION AND ENERGY LOSSES IN MEDIUM CONTAINING ACTIVE MOLECULES  
A65-24811

TRANSITION PROCESSES OF OSCILLATION AMPLITUDE FORMATION IN RF THREE-LEVEL MASERS  
A65-28556

RADIAL DEPENDENCE OF ABSORBED ENERGY DISTRIBUTION IN CYLINDRICAL ROD OF NEODYMIUM GLASS PUMPED WITH XENON SOURCE  
A65-29792

TRANSITION PROBABILITIES FOR AR II LASER LINES COMPARED WITH PREVIOUS THEORETICAL AND EXPERIMENTAL DATA  
A65-29799

STEADY STATE OSCILLATIONS OF LASERS WITH DISTRIBUTED ENERGY LOSSES  
N65-27236

ELECTRON BEAM PUMPED LASERS, DISCUSSING ENERGY DISSIPATION IN FAST ELECTRONS PASSING THROUGH CRYSTAL, LASER SEMICONDUCTOR CHARACTERISTICS, ETC  
A66-23433

## ENERGY SPECTRUM

TIME RESOLVED SPECTRA FOR PULSE OPERATED GALLIUM ARSENIDE LASER DIODES  
A65-33372

## SUBJECT INDEX

COMPTON SCATTERING OF LASER PHOTONS, NOTING TRANSFORMATION INTO GAMMA RADIATION PHOTONS UPON COLLISION WITH HIGH ENERGY ELECTRONS  
A66-17816

## ENERGY STORAGE

FAST HIGH RADIANCE ABLATING LASER PUMP AND ENERGY STORAGE TECHNIQUE  
AFAL-TR-65-22 N65-22702

SINGLE PULSE OPERATION OF LASERS, NOTING ENERGY STORAGE AND AMPLIFICATION EFFECT FOR FOUR- AND THREE-LEVEL ACTIVE MEDIUM  
A66-23667

## ENERGY STORAGE DEVICE

TEXT ON HIGH SPEED OPTICAL PULSE TECHNOLOGY, LASERS AND MEASURING TECHNIQUES, EMPHASIZING CAPACITOR DISCHARGE APPLICATION  
A66-22063

## ENERGY TRANSFER

VIBRATIONAL, ELECTRONIC AND TRANSLATIONAL ENERGY TRANSFERS OF GAS MOLECULE COLLISIONS, NOTING QUENCHING PROCESS AND FREQUENCY DIFFERENCES  
A65-20068

OPTICAL PUMPING ENERGY TRANSFER MECHANISM IN RARE EARTH CHELATES NOTING POSSIBILITY AS LASER MATERIAL  
A65-20075

PULSED AND CONTINUOUS WAVE LASER OPERATION OF THULIUM ION DOPED ERBIUM OXIDE WHICH PROVIDES PUMPING MECHANISM BY MEANS OF ENERGY TRANSFER  
A65-26955

RESONANT ENERGY TRANSFER FROM MERCURY TO ZINC IN GAS LASER  
AD-603680 N65-14200

ENERGY TRANSFER IN RARE EARTH CHELATES - IMPLICATIONS FOR ORGANIC LASER DESIGN  
N65-15505

LASER OSCILLATION INCREASE IN EFFICIENCY IN NEODYMIUM DOPED GLASS PRODUCED THROUGH ENERGY TRANSFER  
A66-10352

OPTICAL DESIGN OF ELLIPTICAL CAVITIES AND COMPARISON OF ENERGY TRANSFERS FROM LIGHT SOURCE TO RUBY LASER WITH CYLINDRICAL CAVITIES  
A66-16647

## ENTROPY

SOME LASER PROPERTIES FROM VIEWPOINT OF SECOND LAW OF THERMODYNAMICS OF IRREVERSIBLE PROCESSES  
A65-31376

SOME LASER PROPERTIES FROM VIEWPOINT OF SECOND LAW OF THERMODYNAMICS OF IRREVERSIBLE PROCESSES  
A66-14899

## EPITAXIAL DEPOSITION

EPITAXIAL DEPOSITION OF GERMANIUM ON GALLIUM ARSENIDE BY HYDROGEN REDUCTION OF GERMANIUM TETRACHLORIDE - SEMICONDUCTOR AND LASER PRODUCTION  
SRRC-RR-65-52 N65-34688

## ERBIUM

YB3- ER3 GLASS THREE LEVEL LASER ACTION  
A65-17208

LASER CHARACTERISTICS OF AND COHERENT OSCILLATIONS FROM TRIVALENT TM, HO, YB AND ER IONS IN YTTRIUM ALUMINUM GARNET  
A66-10241

## ETHANE

ABSORPTION DATA FOR METHANE AND ETHANE, USING HE-NE TUNED LASER SPECTROSCOPY  
A65-20064

## ETHYLENE

REFRACTIVE INDEX OF SOLID DETERMINED, USING FAR-IR MICHELSON INTERFEROMETER ILLUMINATED WITH RADIATION FROM CN MASER  
A65-24683

## ETHYLENE COMPOUND

CARBON AND ETHYLENE TETRACHLORIDE ULTRASONIC MODULATORS APPLIED TO IR LASER HETERODYNE EXPERIMENTS ON IN AS PHOTODIODE

- A66-23353
- EUROPIUM**
- STIMULATED EMISSION AT ROOM TEMPERATURE IN  
EUROPIUM CHELATE SOLUTION A65-21625
- EMISSION SPECTRA OF TRIS AND TETRAKIS FORMS OF  
FOUR BETA-DIKETONE EUROPIUM CHELATES STUDIED FOR  
LIQUID LASER APPLICATION A65-33308
- CHELATE LASER SYSTEMS - EUROPIUM BENZOYLACETONATE  
TR-64-052.7 N65-14405
- EMISSION SPECTROSCOPY AND COORDINATION CHEMISTRY  
OF EUROPIUM CHELATE SOLUTIONS - CHELATE LASERS  
INVESTIGATED FOR EVALUATING POTENTIALITIES OF  
LIQUID LASERS A66-14177
- EUROPIUM COMPOUND**
- ORGANIC CATIONS EFFECT ON LASER THRESHOLD OF  
SOLUTIONS OF TETRAKIS FORM OF EUROPIUM  
BENZOYLTRIFLUOROACETONATE A66-18418
- EXCITATION**
- EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASERS A65-15980
- SEMICONDUCTOR LASER WITH ELECTRON BEAM  
AS EXCITATION SOURCE - EMISSION DATA FOR  
VARIOUS BEAM CURRENT DENSITIES N65-20391
- EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASER, XENON LIFETIMES, AND THEORY OF  
DIFFUSION CONTROLLED GLOW DISCHARGE A65-28779
- DECAY OF LASER-INDUCED EXCITATIONS OF F CENTERS  
IN ALKALI HALIDES A65-34867
- EXCITED STATE**
- MEASUREMENT OF GAS LASER RADIATIVE DECAY RATES AND  
TOTAL INELASTIC DESTRUCTIVE CROSS SECTION OF SHORT  
LIVED EXCITED STATES IN 4-NSEC TO 1000-NSEC RANGE A65-20061
- EXCITED STATE SPECTROSCOPY USING RUBY LASER AND  
LOCALIZED EXCITONS IN ALKALI HALIDES A65-35423
- DECAY OF F-CENTER EXCITATIONS IN ALKALI HALIDES  
INDUCED BY SHORT INTENSE PULSE OF Q-SWITCHED RUBY  
LASER A66-19367
- EXCITED STATE SATURABLE ABSORBER USED WITH  
1.06 MICRON NEODYMIUM GLASS LASER A66-15701
- EXPLORER XXII SATELLITE**
- REFLECTED RADIATION OF Q-SPOILED RUBY LASER FROM  
EXPLORER XXII A65-21306
- EXPLORER SATELLITE**
- ACCURATE TRACKING OF BEACON- EXPLORER ORBITING  
OPTICAL REFLECTORS, USING PULSED RUBY LASER BEAMS A66-19902
- LASER BEAM TRACKING OF BEACON EXPLORER  
SATELLITES A66-22191
- EYE DISEASE**
- CHEMICAL PUMPING OF LASERS - EYE DAMAGE IN  
MONKEYS FROM LASER IRRADIATION A65-13799
- EYE PROTECTION**
- PULSED LASER DOSIMETER THAT MEASURES DANGER LEVEL  
OF RADIATION OF DIRECT OR REFLECTED BEAMS AS  
SAFEGUARD TO EYE DAMAGE A65-21951
- DETERMINATION OF ATTENUATING FILTERS REQUIRED FOR  
EYE PROTECTION AGAINST LASER RADIATION A65-22614
- THRESHOLD INTENSITY OF 8400 ANGSTROM LIGHT FROM  
GALLIUM ARSENIDE LASER DIODE AND EYE DAMAGE
- A65-34663
- HAZARDS, EFFECT, SAFETY AND PRECAUTION FOR  
PREVENTION OF PHYSICAL INJURIES FROM LASER  
RADIATION A66-13694
- F**
- F CENTER**
- DECAY OF LASER-INDUCED EXCITATIONS OF F CENTERS  
IN ALKALI HALIDES A65-34867
- DECAY OF F-CENTER EXCITATIONS IN ALKALI HALIDES  
INDUCED BY SHORT INTENSE PULSE OF Q-SWITCHED RUBY  
LASER A66-19367
- FABRY-PEROT INTERFEROMETER**
- SELF-CONSISTENT FIELD ANALYSIS FOR FIELD  
DISTRIBUTIONS OF RESONANT MODES IN SPHERICAL  
MIRROR FABRY- PEROT RESONATOR A65-16566
- EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS  
BY INCLINING GENERATING SAMPLE WITH RESPECT TO  
INTERFEROMETER AXIS A65-18454
- RESONANCE OSCILLATION IN RUBY LASER EMISSION  
STUDIED BY FABRY- PEROT MULTIPLEX ETALON AS  
FUNCTION OF RESONATOR PROPERTIES A65-24976
- EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS  
BY INCLINING GENERATING SAMPLE WITH RESPECT TO  
INTERFEROMETER AXIS A65-28083
- RESONANT WAVES IN FABRY- PEROT INTERFEROMETER  
INVESTIGATED ON BASIS OF STANDING WAVE TYPE  
FORMULATION A65-33516
- MICROWAVE OR LASER RESONATOR WITH FLAT-ROOF MIRROR  
HAS VERY SMALL DIFFRACTION LOSSES AND IS  
INSENSITIVE TO MISALIGNMENT WHEN ROOF ANGLE IS  
VERY SMALL A65-34606
- FABRY- PEROT INTERFEROMETRIC MODULATOR FOR LASER  
BEAM, MOTING ERROR OF PRECISE ALIGNMENT OF  
REFLECTING SURFACES AND GAUSSIAN TYPE OF  
IMPERFECTIONS A66-12202
- INTENSITY DISTRIBUTION IN FABRY- PEROT  
INTERFEROMETER PRODUCING RESONANT WAVES FOR LARGE  
FRESNEL NUMBER APPLIED IN MODEL FOR FILAMENT-FORM  
LASER MECHANISM A66-13097
- FABRY- PEROT INTERFEROMETER AND CONFOCAL AND  
SPHERICAL RESONATOR, CALCULATING INTEGRAL  
EQUATIONS FOR EIGNVALUE AND EIGENFUNCTION OF  
LOWEST ORDER TW EIGENMODE A66-14277
- ISOTOPE SHIFT MEASUREMENT FOR 6328 ANGSTROMS  
HELIUM-NEON LASER TRANSITION A66-21070
- FABRY-PEROT LASER**
- SPECTRAL LINE SHAPE FOR FABRY- PEROT MASER USING  
VARIOUS OSCILLATION MODES A65-14113
- FABRY- PEROT GALLIUM ARSENIDE LASER HIGHER ORDER  
AXIAL MODE TEMPERATURE DEPENDENCE A65-17655
- SELF-INDUCED OSCILLATIONS IN OUTPUT OF FABRY-  
PEROT GALLIUM ARSENIDE INJECTION LASER A65-21624
- COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM  
OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE  
FABRY- PEROT RESONATOR A65-24088
- DIFFRACTION LOSSES, PHASE SHIFTS AND FIELD  
DISTRIBUTION FUNCTIONS FOR TWO LOWEST-ORDER MODES  
ON INTERFEROMETER-TYPE MASER RESONATORS WITH  
CIRCULAR MIRRORS A65-24911
- SPECTRAL LINE SHAPE FOR FABRY- PEROT MASER USING  
VARIOUS OSCILLATION MODES A65-24933
- JUNCTION REGION HEATING OF FABRY- PEROT GA AS  
INJECTION LASER TREATED BY THREE TECHNIQUES A65-26819



- FABRY- PEROT MULTILAYER LASER AMPLIFIER SOLUTIONS FROM TRANSIENT THEORY POINT OF VIEW, USING LAPLACE TRANSFORM A65-29926
- REFLECTION COEFFICIENT OF CAVITY TUBING AS EXPLANATION FOR POWER LEVEL OF HELIUM-NEON IR FABRY- PEROT INTERFEROMETER A65-30342
- ELECTRIC CIRCUIT ANALOG OPTIMUM DESIGN OF MODE-SELECTIVE MULTIREFLECTOR FABRY- PEROT LASER RESONATORS A65-30344
- OSCILLATION CHARACTERISTICS OF RUBY LASER WITH EXTERNAL MIRRORS OF LARGE SPACING A65-33517
- COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE FABRY- PEROT RESONATORS A65-34909
- THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE LOSSES IN FABRY- PEROT RESONATORS DUE TO MIRROR MISALIGNMENT A65-36053
- PERTURBED AND PLANE PARALLEL FABRY- PEROT RESONATORS, THERMAL FIELDS, QUANTUM OPTICAL COHERENCE, SPONTANEOUS EMISSION, AND DYNAMICAL THEORY OF LASER OSCILLATION A65-27088
- OPTICAL CHARACTERISTICS OF PROTOTYPE LASER MODULATORS WITH THIN, FLAT, DISK-SHAPED FABRY- PEROT INTERFEROMETER DESIGN - LASER RADIATION IN COMMUNICATIONS A65-31681
- MULTIREFLECTOR FABRY- PEROT LASER RESONATORS, DISCUSSING SUPPRESSION EFFECT AGAINST UNWANTED MODES A66-13325
- MICROWAVE MODELS USED TO MEASURE FREQUENCY AND QUALITY FACTORS OF FABRY- PEROT RESONATOR WITH PLANE SQUARE MIRRORS OPERATING IN X-BAND A66-14909
- MODULATION OF LASER LIGHT WITH COMPOSITE FABRY- PEROT RESONATOR, USING MORE THAN THREE MULTIPLE REFLECTING PLATES A66-15836
- THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE LOSSES IN FABRY- PEROT RESONATORS DUE TO MIRROR MISALIGNMENT A66-15856
- MULTIPLE INTERNAL-REFLECTION FOLDED-PATH RECTANGULAR LASER CONFIGURATION FOR OBTAINING LENGTH OF ACTIVE MEDIA BETWEEN FABRY- PEROT REFLECTORS A66-16652
- REFLECTION GRATINGS AS END PLATES IN FABRY- PEROT CAVITY, WITH CHARACTERISTICS OF LOW ABSORPTION OUTPUT COUPLING AND WAVELENGTH-DEPENDENT ALIGNMENT OF END PLATES A66-19930
- SOLID STATE LASER OUTPUT EXHIBITING REGULAR AND IRREGULAR SPIKES ANALYZED THROUGH RELAXATION OSCILLATIONS AND CLASSICAL PHYSICS A66-20568
- LASER INDUCED GAS BREAKDOWN AT HIGH PRESSURES, NOTING EFFECT OF PLASMA DENSITY ON INDEX OF REFRACTION VIA OPTICAL FREQUENCY RESONANCE MEASUREMENT A66-21564
- FAR FIELD**
- FAR FIELD PATTERNS OF OFF-AXIAL MODES IN CYLINDRICAL GLASS NEODYMIUM LASER RODS A65-34807
- BEAM DIVERGENCE AND FAR-FIELD PATTERNS OF RUB RODS OF VARYING OPTICAL QUALITY A65-35315
- FAR INFRARED**
- FAR IR GAS MASER OSCILLATOR DISCUSSING ENERGY LEVELS, PUMPING MOLECULAR RADIATION AND DETECTION A65-18849
- HELIUM-XENON AND KRYPTON-XENON GAS LASERS OPERATING IN FAR IR A65-26727
- GAS MASER PUMP ANALOGOUS TO OPERATION OF HEAT ENGINE FOR EXCITING MASER ACTION IN FAR IR, DETAILING INTERACTION BETWEEN PURE ROTATIONAL STATES OF H CL AND HF A65-35312
- PULSED GAS LASER FOR FAR INFRARED REGION OF SPECTRUM N65-20170
- FARADAY EFFECT**
- LIGHT DIFFRACTION BY GRATING DUE TO FARADAY AND KERR EFFECT IN ELECTROMAGNETIC FIELD OF LASER BEAM A65-26582
- LONGITUDINAL MAGNETIC FIELD EFFECT UPON GAS DISCHARGE, ZEEMAN EFFECT AND FARADAY EFFECT IN HE- NE GAS LASER A66-24224
- FEEDBACK AMPLIFIER**
- PLANE STATIONARY MODE OF TW LASER AMPLIFIER WITH FEEDBACK A65-19683
- FEEDBACK CONTROL SYSTEM**
- AUTOMATIC FEEDBACK CONTROL FOR LONG-TERM FREQUENCY STABILIZATION OF HE- NE LASER AT CENTER FREQUENCY OF ATOMIC RESONANCE A65-21620
- FERROELECTRICS**
- OPTICAL PHASE MODULATOR USING FERROELECTRIC BARIUM TITANATE CRYSTAL PLATE A66-10240
- GADOLINIUM MOLYBDENATE AS FERROELECTRIC HOST IN PULSED LASER, NOTING LIGHT MODULATION AND CRYSTAL COMAIN A66-23207
- FERROMAGNETIC FILM**
- HELIUM-NEON GAS LASER AS LIGHT SOURCE FOR MAGNETO-OPTICAL APPARATUS - KERR MAGNETO-OPTICAL EFFECT OF FERROMAGNETIC IRON-NICKEL THIN FILM N65-26766
- FERROMAGNETISM**
- RESEARCH IN FERROMAGNETISM, POLYMER CHEMISTRY, LASERS, SEMICONDUCTORS, AND SOLID STATE SPECTROSCOPY N65-26765
- MICROWAVE RADIATION RESEARCH - ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASERS, SEMICONDUCTOR OSCILLATIONS, RAMAN SCATTERING, FERROMAGNETIC BULK INSTABILITIES, AND NONUNIFORM PLASMAS N66-22741
- FIBER OPTICS**
- WAVEGUIDE COUPLING BETWEEN ADJACENT PARALLEL FIBERS AS MEANS OF TRANSFERRING RADIATION FROM ONE ELEMENT TO ANOTHER A66-14827
- FRAUNHOFER PATTERN OF LASER LIGHT TRANSMITTED THROUGH OPTICAL FIBER, NOTING SPATIAL FREQUENCY OF INTERFERENCE FRINGES BETWEEN LIGHT WAVES A66-14972
- LARGE ANGLE DEFLECTION TECHNIQUE FOR PRODUCING 945-LINE TELEVISION TYPE RASTER SCAN IN DISPLAY SYSTEM - ELECTRO-OPTICS, LASERS, AND FIBER OPTICS N66-14858
- FILM CONDENSATION**
- LOW-LOSS MULTILAYER DIELECTRIC COATINGS BY FILM DEPOSITION FOR LASER MIRROR A65-29525
- FIRING**
- PULSED LASER FOR SIMULATING TANK GUN FIRING FOR TRAINING OF TANK GUNNERS N65-34674
- XENON FLASH TUBE FIRING SYSTEM FOR LASERS N66-20553
- FLAME**
- FLAME EMISSION DATA AND ABSORPTION CHARACTERISTICS SUITABLE FOR POPULATION INVERSION FOR LASER ACTION, NOTING LOW PRESSURE OXYACETYLENE FLAME A65-20070
- FLASH TUBE**
- GAS LASER CROSS MODULATION EFFECT WHEN EXPOSED TO FLASH TUBE RADIATION A65-15324

- OPTIMIZING FLASH LAMPS FOR PUMPING LASER RODS  
BY MEANS OF DOPING  
AD-613346 N65-25890
- OPACITY MEASUREMENT OF XENON FLASH TUBE - OPTICAL  
MASER  
NASA-CR-56917 N65-35256
- EXCITATION OF RUBY LASERS USING DOUBLE-PUMPED  
HIGH-INTENSITY HELICAL FLASH TUBES, OBTAINING  
TIME-RESOLVED SPECTRA OF ELECTRICAL DISCHARGES AND  
PLASMA TEMPERATURES A66-11446
- DISMOUNTABLE FLASH LAMP FOR LASER, INCLUDING CROSS  
SECTIONAL SCALE DRAWING AND WIRING DIAGRAM  
A66-23296
- EFFICIENT CONVERSION OF ELECTRICAL ENERGY INTO  
LASER RADIATION, USING COAXIAL OPTICAL PUMP  
A66-23479
- XENON FLASH TUBE FIRING SYSTEM FOR LASERS  
BNL-9257 N66-20553
- FLASH PHOTOLYSIS APPARATUS FOR STUDYING SHORT  
LIVED CHEMICAL INTERMEDIATES FROM METHYLENE BLUE  
PSL-102 N66-21833
- FLOW METER  
LASER FLOW METER FOR MEASUREMENT OF LOCAL VELOCITY  
IN CONTAMINATED GAS FLOW FIELDS - DOPPLER SHIFT  
TECHNIQUE  
R-149 N65-26015
- FLOW VELOCITY  
LASER DOPPLER FLOWMETER MEASUREMENT TECHNIQUE  
FOR LOCALIZED FLOW VELOCITIES IN GAS, NOTING  
RELIABILITY FOR HIGH FLOW VELOCITIES  
A65-35061
- FLOW VISUALIZATION  
ADVANTAGES OF GAS LASERS AS LIGHT SOURCES IN  
AERODYNAMIC RESEARCH INTERFEROMETERS  
A66-16944
- CONVENTIONAL FLOW VISUALIZATION USING LASER LIGHT  
SOURCE  
AIAA PAPER 66-127 A66-17104
- FLUID AMPLIFICATION  
LIFE SUPPORT SYSTEM, FLUID AMPLIFICATION,  
SPALLING, COMMUNICATIONS SATELLITE, MICROWAVE  
APPARATUS, HIGH STRENGTH STEEL, TRACERS, LASERS,  
ATMOSPHERIC TURBULENCE, AND RESONANCE  
AD-611432 N65-22732
- FLUID MECHANICS  
FLUID MECHANICS, LUBRICATION, CORROSION, MASERS,  
BIOLOGICAL STRESS, PROTECTIVE COATINGS, NEUTRON  
ACTIVATION, FRACTOGRAPHY, METABOLISM, GUIDED  
MISSILE LAUNCHING, AND CATAPULTS  
AD-623630 N66-14468
- FLUID ROTOR GYROSCOPE  
INERTIAL SENSORS REVIEWING RING LASER,  
ELECTROSTATIC FLUID SPHERE, MAGNETIC RESONANCE,  
SUPERCONDUCTIVITY GYROSCOPE, RELATIVISTIC ROTATING  
TENSOR, VORTEX RATE AND QUANTUM MECHANICAL EFFECT  
SENSING  
AIAA PAPER 65-401 A65-29669
- FLUORESCENCE  
STIMULATED EMISSION IN FLUORESCENT ORGANIC  
MOLECULES N65-15504
- NEODYMIUM DOPED LASER GLASS COMPARED ON BASIS OF  
FLUORESCENCE CHARACTERISTIC DIFFERENCES  
AD-612459 N65-25901
- MONTE CARLO METHOD FOR CALCULATION OF EFFECTIVE  
FLUORESCENT LIFE TIMES FOR RUBY LASER RODS WITH  
BREWSTER ANGLE ENDS AND ROUGHENED SIDES  
UCRL-7765-T/REV. 1/ N65-32343
- RUBY LASER RADIATION EFFECT ON FLUORESCENCE AND  
LASER ACTION IN DYSPROSIUM DOPED CALCIUM FLUORIDE  
CRYSTALS A66-10718
- OPTICAL WHISPERING MODE OF POLISHED CYLINDERS AND  
IMPLICATION IN LASER TECHNOLOGY, NOTING TRAPPED  
FLUORESCENT LIGHT A66-12203
- FLUORESCENT EMISSION  
EMISSION AND ABSORPTION PROFILES FOR RUBY R SUB 1  
LINES SHOW ABSENCE OF SIGNIFICANT STOKES SHIFT  
A65-17664
- ATOMIC AND MOLECULAR FLUORESCENCE EXCITED BY  
PHOTODISSOCIATION, DISCUSSING LINE STRENGTH AND  
DOPPLER WIDTH A65-20073
- FLUORESCENT ORGANIC LASER DEVELOPMENT - THETA  
PINCH ARGON LAMP MEASUREMENTS  
CR-7 N65-25966
- FLUORINATION  
APPARATUS FOR FLUORIDATION OF HYDROXYL AND OXYGEN  
CONTAMINATED FLUORIDE COMPOUNDS, OBTAINING  
OPTICALLY CLEAR CRYSTALS WITH NO TYNDALL  
SCATTERING FOR LASER APPLICATION  
A66-18488
- FLUORINE COMPOUND  
APPARATUS FOR FLUORIDATION OF HYDROXYL AND OXYGEN  
CONTAMINATED FLUORIDE COMPOUNDS, OBTAINING  
OPTICALLY CLEAR CRYSTALS WITH NO TYNDALL  
SCATTERING FOR LASER APPLICATION  
A66-18488
- FLUORO COMPOUND  
GAS LASER OUTPUT AND THRESHOLD IN POPULATION  
INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE  
AND FLUORO IODO METHYLYLDIYNE A66-16771
- FLUX  
COMPUTER ANALYSIS DETERMINING CHANGE OF POPULATION  
INVERSION AND OUTPUT PHOTON FLUX AND EXPERIMENT  
USING RUBY FOR OSCILLATOR AND AMPLIFIER USING  
TRAVELING WAVE MASER IN TRIANGULAR CONFIGURATION  
GSP/PHYS/65-14 N65-31091
- FLUX DENSITY  
HEATING PROCESS IN LASER WELDING OF METAL SHEETS,  
TAKING INTO ACCOUNT ENERGY DISTRIBUTION, HEAT  
TRANSFER AND FLUX DENSITIES A66-15347
- FOCUS  
INTEGRAL REPRESENTATION FOR ELECTROMAGNETIC FIELD  
IN FOCAL REGION OF COHERENT LIGHT BEAM EMERGING  
FROM APLANATIC OPTICAL SYSTEM A65-27092
- FOCUSING  
SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-14131
- FOCUSING AND COLLIMATION PROPERTIES OF PULSED  
MULTIMODING RUBY LASER  
REPT.-1579-19 N65-21554
- FOG  
FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS  
SYSTEMS, PRIMARILY LIGHT ABSORPTION AND  
ATMOSPHERIC SCATTERING A65-15349
- LASER FOG DISDROMETER FOR MEASURING DROPLET SIZE  
IN FOG A65-17644
- FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS  
SYSTEMS, PRIMARILY LIGHT ABSORPTION AND  
ATMOSPHERIC SCATTERING A65-32353
- FOKKER-PLANCK EQUATION  
NONLINEAR THEORY OF LASER NOISE WITH CORRELATION  
FUNCTIONS DERIVED FROM DISTRIBUTION FUNCTIONS  
OBTAINED BY FOKKER- PLANCK EQUATION A65-27759
- CORRELATION FUNCTIONS OF AMPLITUDE AND INTENSITY  
FLUCTUATION FOR LASER MODEL NEAR THRESHOLD  
OBTAINED BY USING DISTRIBUTION FUNCTIONS EVALUATED  
BY FOKKER- PLANCK EQUATION, TREATING AMPLITUDE AS  
RANDOM VARIABLE A66-25018
- FORBIDDEN BAND  
EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER  
WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF  
FORBIDDEN BAND IN GALLIUM ARSENIDE A65-31307

## FORMATION

EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF FORBIDDEN BAND IN GALLIUM ARSENIDE

A65-33354

## FORMATION

FORMATION TIME OF OPTICAL LASER OSCILLATIONS

N66-15050

## FORTRAN

LIGHT SCATTERING IN SEA WATER - FORWARD SCATTERING OF LASER BEAM IN SEA WATER AND FORTRAN PROGRAM SCATTERING CALCULATIONS

AD-610126

N65-23316

## FORWARD SCATTER

MULTICHANNEL PHOTOELECTRIC SPECTRUM ANALYZER WITH KERR CELL GATING RECORDS SPECTRUM OF LASER LIGHT SCATTERED FROM SINGLE GIANT PULSE IN PLASMA

A65-28203

LIGHT SCATTERING IN SEA WATER - FORWARD SCATTERING OF LASER BEAM IN SEA WATER AND FORTRAN PROGRAM SCATTERING CALCULATIONS

AD-610126

N65-23316

## FRACTOGRAPHY

FLUID MECHANICS, LUBRICATION, CORROSION, MASERS, BIOLOGICAL STRESS, PROTECTIVE COATINGS, NEUTRON ACTIVATION, FRACTOGRAPHY, METABOLISM, GUIDED MISSILE LAUNCHING, AND CATAPULTS

AD-623630

N66-14468

## FRACTURE MECHANICS

FRACTURES IN NEODYMIUM-DOPED ALKALINE SILICATES AND BOROSILICATES PRODUCED BY LASER BEAM

A66-14174

## FRANCK-CONDON FACTOR

FEASIBILITY OF LASER OPERATING ON VIBRATIONAL - TRANSITIONS - SCHEMES USING FRANCK-CONDON PRINCIPLE

VARIAN-314-3S

N65-28168

## FRAUNHOFER LINE

FRAUNHOFER PATTERN OF LASER LIGHT TRANSMITTED THROUGH OPTICAL FIBER, NOTING SPATIAL FREQUENCY OF INTERFERENCE FRINGES BETWEEN LIGHT WAVES

A66-14972

## FREE ELECTRON

ION AND FREE ELECTRON PRODUCTION RATE STUDY IN GAS UNDER LASER BEAM ACTION

A65-19727

## FREON

LASER EXCITATION IN FREON AND RARE GAS MIXTURES BASED ON DISSOCIATIVE EXCITATION PROCESS AND QUENCHING ACTION OF SOME GASES

A65-35043

## FREQUENCY BAND

BEHAVIOR OF COUPLING-TYPE INTERNAL LASER MODULATORS WITH BANDWIDTH COMPARABLE TO MODE SPACING

A65-16404

COHERENT LIGHT RECORDING AND REPRODUCING SYSTEM COMPRISING TWO-DIMENSIONAL QUANTUM MECHANICAL DATA PROCESS OF ULTIMATE PACKING DENSITY AND FREQUENCY BANDWIDTH

RADC-TR-65-130

N65-35528

## FREQUENCY CONTROL

REDUCTION OF LOCKING FREQUENCY OF RING LASER BY MAKING TWO BEAMS ORTHOGONAL

A65-19601

DESIGN AND CONSTRUCTION OF STABLE SINGLE FREQUENCY RF EXCITED HE- NE LASER AT 6328 ANGSTROMS

A65-35358

CONTROLLING FM AND SUPERMODE LASER OUTPUT FREQUENCIES BY THRESHOLD CONTROL AND INTERFEROMETRIC CONTROL

A65-36842

FREQUENCY STABILIZATION IN VISIBLE SPECTRUM OF GAS LASER USED AS OPTICAL PUMP GAIN MODULATOR

NASA-CR-64359

N65-31013

STABLE SINGLE-FREQUENCY OUTPUT FROM LASER CAVITY OBTAINED BY FILTER METHOD AND RESONANCE SUPPRESSION METHOD

A66-18356

## SUBJECT INDEX

FREQUENCY STABILIZATION OF GAS LASERS, USING ATOMIC RESONANCE AND INTERFEROMETERS

A66-18357

## FREQUENCY CONVERSION

LIGHT WAVE FREQUENCY CONVERSION BY LASER CRYSTAL, EXAMINING RESULTANT HARMONICS

A65-15508

PARAMETRIC CONVERSION OF OPTICAL FREQUENCIES IN CRYSTAL ILLUMINATED BY LASERS

A65-28626

EQUATIONS DESCRIBING HEAT FREQUENCY VARIATION AND MODE COMPETITION IN GASEOUS LASER OPERATED IN MAGNETIC FIELD PARALLEL TO LASER AXIS

A65-30303

## FREQUENCY CONVERTER

COHERENT AND INCOHERENT OUTPUT CURVE OF THREE-LEVEL QUANTUM FREQUENCY CONVERTER

A65-17505

## FREQUENCY DISTRIBUTION

LASER CAVITY ANALYSIS, THRESHOLD MEASUREMENTS, FREQUENCY DISTRIBUTION, MODE DENSITY, AND SPIKING STRUCTURE

AFCRL-65-481

N65-32298

## FREQUENCY MEASUREMENT

GAS LASER MOLECULAR ABSORPTION DISCRIMINATION OF CLOSE FREQUENCIES

A65-15998

FREQUENCY SPECTRA MEASUREMENT OF GASEOUS LASER BY PHOTOMIXING TECHNIQUES AND NOISE DISTRIBUTION

A65-16405

SHORT-TERM FREQUENCY INSTABILITY AND FREQUENCY SPECTRA OF HIGHLY STABLE QUARTZ OSCILLATORS MEASURED, USING DOUBLE-BEAM AMMONIA MASER AS STANDARD

A65-18320

GAIN COEFFICIENTS AND MEASUREMENTS IN LASER AMPLIFIER, AND SOLID STATE LASER MATERIALS

GR-6

N65-14465

ABSOLUTE WAVELENGTH STABILITY OF HELIUM-NEON LASER MEASURED BY DIRECT INTERFEROMETRIC COMPARISON WITH HG 198 STANDARD LAMP

A66-22868

DIRECT FREQUENCY COMPARISON OF ATOMIC HYDROGEN MASERS IN DIFFERENT PLACES AND CONDITIONS BY SIMULTANEOUS MONITORING OF LORAN C SIGNALS

A66-24145

## FREQUENCY MODULATION

GENERATION OF SINGLE FREQUENCY LIGHT USING FM LASER

A65-16670

AUTOMATIC FEEDBACK CONTROL FOR LONG-TERM FREQUENCY STABILIZATION OF HE- NE LASER AT CENTER FREQUENCY OF ATOMIC RESONANCE

A65-21620

LASER OSCILLATION WHEREIN LASER MODES OSCILLATE WITH APPROXIMATELY FM PHASES THEREBY COMPRISING SIDEBANDS OF FM LIGHT SIGNAL

A65-21876

SUPERMODE LASER AS SINGLE-FREQUENCY GENERATION SYSTEM CONSISTING OF FM LASER WITH SYNCHRONOUS PHASE MODULATOR AT OUTPUT

A65-29267

ATMOSPHERIC TURBULENCE EFFECT ON OPERATION OF DUAL-POLARIZATION FM LASER COMMUNICATION SYSTEM

A65-33377

SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION, CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION, FREQUENCY MODULATION LASERS, AND GALLIUM COMPOUND INGOTS FOR LASER APPLICATION

AFCRL-64-1007

N65-23135

FREQUENCY MODULATION LASER WITH COMPOSITE AXIAL MODES

N65-23138

CARRIER FREQUENCY STABILIZATION OF FM LASER WITH RESPECT TO CENTER OF ATOMIC GAIN PROFILE, USING SMALL DISTORTION PRESENT IN LASER OSCILLATION

A66-10966

F M LASER OSCILLATION THEORY DISCUSSING EFFECT OF ARBITRARY ATOMIC LINE SHAPE, SATURATION, MODE

# SUBJECT INDEX

# FUSION WELDING

- PULLING, POWER OUTPUT, SIDEBAND AMPLITUDE, DISTORTION, ETC A66-13954
- EXPERIMENTS ON HELIUM-NEON FM LASERS COVERING PHASE-LOCKED AND FM REGION POWER OUTPUT, MODULATION INDEX AND DISTORTION EXPERIMENTS A66-13955
- FREQUENCY-SELECTIVE TRANSMISSION ETALON REPLACES END MIRROR OF FM LASER SO THAT TOTAL POWER IS OBTAINED AS SINGLE OPTICAL FREQUENCY A66-16381
- PHASE-LOCKING EFFECT AND PHASE SUM OF LF AND HF OSCILLATING MODES IN LASER A66-18413
- SEMICONDUCTOR LASERS, FM TECHNIQUES AND MULTIPLE-SCATTER PATHS USED TO OVERCOME MODULATION NOISE UNDER VARYING WEATHER CONDITIONS A66-19915
- PROPERTIES OF FREQUENCY MODULATION AND SUPER MODE LASER IER-1 N66-10766
- EXPERIMENTAL AND THEORETICAL PROGRAM TO DETERMINE FUNDAMENTAL PROPERTIES OF FREQUENCY MODULATION AND SUPER-MODE LASERS IER-2 N66-21405
- COHERENT LIGHT COMMUNICATION SYSTEM FOR ATMOSPHERE CONDITION EFFECTS ON FREQUENCY MODULATED LASER BEAM FR-66-14-37 N66-21774
- FREQUENCY MULTIPLIER**  
OUTPUT FREQUENCY QUADRUPLING IN Q-SPOILED NEODYMIUM-IN-GLASS LASER, USING NONLINEAR OPTIC EFFECT A65-15858
- FREQUENCY RANGE**  
PUMP FREQUENCY OF 30 GIGACYCLES USING HARMONIC CROSS RELAXATION ON CHROMIUM DOPED RUTILE TO OBTAIN POPULATION INVERSION AT 40 GIGACYCLE SIGNAL FREQUENCY A65-25873
- ELECTRON BEAMS, PLASMA, AND LASERS AND MASERS FOR EXTENDING USEFUL FREQUENCY SPECTRUM INTO RANGE FROM MICROWAVE TO OPTICAL FREQUENCIES MDL-Q12 N65-28149
- CROSS CORRELATION MEASUREMENTS OF OSCILLATOR FREQUENCY STABILITY AND THERMAL NOISE AND APPLICATION TO ATOMIC HYDROGEN MASER A66-24128
- DEPENDENCE OF BEAT FREQUENCY OF NEODYMIUM LASER AXIAL MODES ON DISTANCE BETWEEN MIRRORS AND NEODYMIUM ROD POSITION WITHIN RESONATOR A66-24881
- FREQUENCY RESPONSE**  
FREQUENCY RESPONSE AND CROSS COUPLING OF RED AND IR GAS LASER INTERFEROMETER FOR MEASURING PLASMA ELECTRON DENSITY A65-15819
- SPIKING BEHAVIOR OF MULTIMODE RUBY LASER IN SPHERICAL RESONATOR, INTERPRETING NEAR-FIELD PATTERNS, FREQUENCY SPECTRUM, ETC A66-21311
- LASER PROPERTIES RELEVANT TO MEASUREMENT OF PHYSICAL PARAMETERS - MAPPING VIBRATING SURFACE, FREQUENCY RESPONSE OF TRANSDUCER, SENSITIVE LEVEL, PRESSURE DETERMINATION, AND HOLOGRAMS NASA-CR-68235 N66-12860
- FREQUENCY SHIFT**  
RUBY LASER POWER DEPENDENCE ON FREQUENCY SPLITTING OF TWO COMPONENTS OF R1 DOUBLET AT 77 DEGREES K A65-17654
- OUTPUT OF SINGLE MODE GAS LASER IN AXIAL MAGNETIC FIELD STUDIED FOR INCREASE IN FREQUENCY STABILITY A65-26954
- INTERFEROMETER TUNING EFFECT ON ZEEMAN BEAT FREQUENCY IN RADIATION OF HELIUM-NEON LASER WITH APPLIED MAGNETIC FIELD A65-26956
- FREQUENCY SEPARATION BETWEEN TRANSVERSE MODES OF RUBY LASER MEASURED BY FABRY-PEROT INTERFEROMETER AND VERIFIED BY TRANSVERSE MODE SELECTION A65-27610
- RUBY LASER MODULATION AT ATOMIC LEVEL - FREQUENCY SHIFT MEASUREMENT OF LASER EMISSION UNDER INHOMOGENEOUS MAGNETIC FIELD BY SPECTROSCOPY NASA-CR-57464 N65-19863
- RAMAN LASER MATERIALS SELECTION, EMPHASIZING FREQUENCY SHIFTS AND EXCITATION POWER THRESHOLD A66-23477
- FREQUENCY STANDARD**  
HYDROGEN MASER AND CESIUM BEAM TUBE FREQUENCY STANDARDS COMPARED A65-16680
- FREQUENCY STANDARDS OF HYDROGEN MASER AND SWISS CESIUM ATOMIC BEAM TUBE COMPARED A65-16681
- PHOTOBAT CHARACTERISTICS BETWEEN TWO INDEPENDENTLY STABILIZED HE- NE LASERS A65-29117
- FREQUENCY STABILIZATION OF DOUBLE MODE HELIUM-NEON LASER VIA PHASE LOCK CIRCUIT A65-29411
- COMPACT SOLID STATE CESIUM LASER BEAM FREQUENCY STANDARD FOR PRECISION CLOCKS N65-26681
- ZEEMAN EFFECT MODULATION OF AMMONIA MASER FOR FREQUENCY STANDARD N65-26685
- OPTICALLY PUMPED RUBIDIUM 87 MASER OSCILLATOR A66-24124
- STATISTICAL ANALYSIS OF NOISE QUALITY OF ATOMIC FREQUENCY STANDARDS INCLUDING MASERS A66-24130
- COMPARISON OF HYDROGEN MASER AND OF CESIUM BEAM TUBE FREQUENCY STANDARD NASA-TN-D-3292 N66-21698
- FREQUENCY TRANSLATION SYSTEM**  
OPTICAL SECOND HARMONIC GENERATION APPLIED TO HIGH POWER COHERENT SOURCE FREQUENCY TRANSLATION IN COMMUNICATIONS SYSTEMS A65-19176
- SYSTEM TRANSLATING FREQUENCY OF GAS LASER OVER RANGE OF SEVERAL GIGACYCLES, ELIMINATING NEED FOR ELECTRO-OPTIC CRYSTALS WITH CUBIC SYMMETRY A65-25872
- OPTICAL FREQUENCY TRANSLATION TECHNIQUES LEADING TO DESIGN OF Y-SHAPED LASER CONFIGURATION AB-1272-0013 N65-15259
- FRINGE**  
SPIRAL FRINGES IN INTERFERENCE PATTERN OF INTERFEROMETER WITH LASER ILLUMINATION AS INDICATION OF DISCONTINUITY IN WAVE FRONT OR GENERATING SURFACE A65-33430
- FRINGE COUNTING MICHELSON INTERFEROMETER USING HELIUM-NEON GAS LASER FOR INDUSTRIAL LENGTH MEASUREMENT SCL-CC-65-92 N66-20322
- FUSION**  
THERMONUCLEAR FUSION CONTROL FOR ELECTRIC POWER CONVERSION - THETA PINCH, ION CYCLOTRON, AND INFRARED MASER DIAGNOSTICS N65-24859
- FUSION WELDING**  
LASER BEAM WELDING ELECTRONIC-COMPONENT LEADS A66-14517
- LASER WELDING EVALUATED WITH REGARD TO PERFORMANCE AND PRODUCTION APPLICATION A66-14692
- PULSED LASER WELDING, WIRE-TO-WIRE, SHEET-TO-SHEET, CIRCUIT BOARD, VACUUM TUBE, ETC A66-18153

## G

## GADOLINIUM

GADOLINIUM MOLYBDENATE AS FERROELECTRIC HOST IN PULSED LASER, NOTING LIGHT MODULATION AND CRYSTAL DOMAIN A66-23207

## GAIN

GAIN COEFFICIENTS AND MEASUREMENTS IN LASER AMPLIFIER, AND SOLID STATE LASER MATERIALS QR-6 N65-14465

## GALACTIC RADIO WAVE

MULTICAVITY RADIOMETER MASERS FOR RECORDING 21 CM EMISSION FROM GALACTIC HYDROGEN N65-18885

## GALLIUM

GROWTH OF BROAD LINewidth RUBY SINGLE CRYSTALS FROM FLUX AND ADDITION OF GALLIUM FOR HIGH OPTICAL LASERS R-11-454 N65-28525

## GALLIUM ALLOY

HIGH POWER GALLIUM-ARSENIC INJECTION LASER DIODES AD-621649 N66-13744

## GALLIUM ANTIMONIDE

RECOMBINATION RADIATION FROM GALLIUM ANTIMONIDE P-N JUNCTIONS, OBSERVING STIMULATED EMISSION AND LASER ACTION A65-30572

## GALLIUM ARSENIDE

STIMULATED EMISSION EVIDENCE FROM NITROGEN COOLED SPIKING RUBY-LASER-IRRADIATED DEGENERATED P-TYPE GA AS CRYSTALS A65-15323

CIRCUITRY, MECHANICAL CONSTRUCTION AND PRELIMINARY PERFORMANCE OF GALLIUM ARSENIDE LASER TRANSMITTER OPERATED AT ROOM TEMPERATURE A65-15327

INJECTION DIODE LASER FROM DEGENERATED GALLIUM ARSENIDE WITH NEODYMIUM DOPED LAYER EMITTING AT 8700 ANGSTROMS A65-15995

FABRY-PEROT GALLIUM ARSENIDE LASER HIGHER ORDER AXIAL MODE TEMPERATURE DEPENDENCE A65-17655

CURRENT DISTRIBUTION CONTROL IN GALLIUM ARSENIDE INJECTION LASER SHOWING EFFECTS ON OSCILLATION MODE AND THRESHOLD A65-17665

LASER EMISSION FROM N TYPE GALLIUM ARSENIDE CRYSTAL BY FAST ELECTRON EXCITATION, NOTING DOPING AND EMISSION ENERGY A65-19546

SELF-INDUCED OSCILLATIONS IN OUTPUT OF FABRY-PEROT GALLIUM ARSENIDE INJECTION LASER A65-21624

PHYSICAL CONDITIONS FOR OBTAINING LASER EFFECT IN P-N JUNCTION AND TECHNOLOGY IN CONSTRUCTING LASER DEVICES A65-23847

PERFORMANCE CHARACTERISTICS OF GALLIUM ARSENIDE AND MIXED-CRYSTAL INJECTION LASERS SURPASS ALL OTHER LASERS IN EFFICIENCY AND CW POWER OUTPUT A65-24130

JUNCTION REGION HEATING OF FABRY-PEROT GA AS INJECTION LASER TREATED BY THREE TECHNIQUES A65-26819

LASER ACTION IN ALLOYED GALLIUM ARSENIDE JUNCTION DIODE SUBMERGED IN LIQUID NITROGEN A65-29198

GALLIUM ARSENIDE LASER DIODES BEHAVIOR AT HIGH PULSE RADIATION LOADS A65-29356

LASER CURRENT-MONITORING DEVICE, SMALL CURRENT TRANSFORMER FEEDS SOLID-STATE PULSE-CODING DEVICE WHICH MODULATES GALLIUM-ARSENIDE LASER A65-29885

EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF

## FORBIDDEN BAND IN GALLIUM ARSENIDE

A65-31307

TEMPERATURE RISE AT GA AS LASER JUNCTION FOR VARIOUS PULSE CURRENTS AND BASE TEMPERATURES A65-31732

OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER AS AIRCRAFT ALTIMETER TO ELIMINATE SPURIOUS ECHOES A65-32588

EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF FORBIDDEN BAND IN GALLIUM ARSENIDE A65-33354

TIME RESOLVED SPECTRA FOR PULSE OPERATED GALLIUM ARSENIDE LASER DIODES A65-33372

OPTICAL GAIN AND LOSSES OF GA AS LASER OF EPITAXIAL AND DIFFUSED TYPE A65-33380

TIME PARAMETERS OF POWERFUL LASER MEASURED WITH GA AS PHOTODIODE, NOTING TIME CONSTANT AND TIME RESOLUTION OF PHOTODIODE A65-34552

THRESHOLD INTENSITY OF 8400 ANGSTROM LIGHT FROM GALLIUM ARSENIDE LASER DIODE AND EYE DAMAGE A65-34663

RADIATIVE TRANSITION PROCESS IN EMISSION SPECTRUM OF GALLIUM ARSENIDE P-N JUNCTION LASER DIODES A65-34666

INTENSITY FLUCTUATIONS MEASURED IN EMISSION FROM VARIOUS LASING AND NONLASING MODES OF CONTINUOUS WAVE GA AS LASER A65-34687

INDUCED RADIATION IN GA AS SEMICONDUCTOR CRYSTAL EXCITED BY RUBY LASER WITH Q-MODULATION A65-35842

INDUCED RADIATION AND LASER ACTION OF GALLIUM ARSENIDE SINGLE CRYSTAL EXCITED BY LIGHT FROM Q-MODULATED RUBY LASER A65-36362

GALLIUM ARSENIDE LUMINESCENT DIODES WITH TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION AT HIGH DENSITY CURRENT A65-36787

GALLIUM ARSENIDE LASER DIODES FABRICATED BY DIFFUSION OF ZINC QPR-1 N65-17442

COMPACT PULSE GENERATOR FOR DRIVING GALLIUM ARSENIDE LASERS AT ROOM TEMPERATURE N65-20175

DESIGN OF COMPACT 100 WATT GALLIUM ARSENIDE LASER TRANSMITTER N65-20177

STIMULATED EMISSION FROM GALLIUM ARSENIC P-N JUNCTION LASERS N65-20780

MODULATION INDUCING RETRODIRECTING OPTICAL SYSTEM - DIODE MOUNT FOR GALLIUM ARSENIDE LASERS, AND GENERATION OF ALKALINE LINE BY STIMULATED RAMAN EMISSION NASA-CR-57922 N65-21342

GALLIUM ARSENIDE ALLOY INGOT PREPARATION BY VAPOR TRANSPORT METHODS FOR LASER APPLICATIONS N65-23139

IMPROVEMENT OF P-N JUNCTION IN GALLIUM ARSENIDE BY INCREASING QUANTUM EFFICIENCY FOR DIRECT CURRENT STIMULATED ELECTROLUMINESCENCE - LASERS AD-461889 N65-26930

GROWTH OF GALLIUM ARSENIDE-PHOSPHIDE COMPOUNDS FOR LASER USE AFCL-65-271 N65-27833

EXTERNAL POWER EFFICIENCY OF GALLIUM ARSENIDE LASER DIODES QPR-2 N65-32069

METHODS OF JUNCTION FORMATION TO OBTAIN ROOM TEMPERATURE GALLIUM ARSENIDE LASER DIODES

## SUBJECT INDEX

## GAS DISCHARGE

QPR-3 N65-34184

EPITAXIAL DEPOSITION OF GERMANIUM ON GALLIUM  
ARSENIDE BY HYDROGEN REDUCTION OF GERMANIUM  
TETRACHLORIDE - SEMICONDUCTOR AND LASER  
PRODUCTION  
SRRC-RR-65-52 N65-34688

SEMICONDUCTOR INJECTION LASERS AND LAMPS  
RAE-TR-65095 N65-36334

LASER TRANSITION IDENTIFICATION IN ELECTRON BEAM  
PUMPED GALLIUM ARSENIDE, PRIMARILY ON  
CONCENTRATION OF SHALLOW DONORS AND ACCEPTORS  
A66-10348

GALLIUM ARSENIDE INJECTION LASER FOR PROLONGED  
OPERATION AT LIQUID NITROGEN TEMPERATURES  
A66-10369

THERMAL LIMITATIONS ON CAPABILITIES OF GALLIUM  
ARSENIDE P-N JUNCTION LASERS A66-10895

LASER-ACTION THRESHOLD IN ELECTRON-BEAM EXCITED  
GALLIUM ARSENIDE AND EFFECT OF TEMPERATURE AND  
DOPING A66-10971

CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW  
A66-11190

GA AS OPTICALLY COUPLED TRANSISTOR STRUCTURE WITH  
LASING EMITTER A66-12442

OPTICALLY CONNECTED LASER CONSTRUCTED ON GALLIUM  
ARSENIDE P-N JUNCTION, NOTING COHERENT RADIATION  
A66-14363

GALLIUM ARSENIDE P-N JUNCTION LASER DIODE COVERING  
INJECTION CURRENT DISTRIBUTION, DENSITY AND  
EMISSION SPECTRA VARIATION A66-14659

SHIFT OF EMISSION SPECTRUM IN PULSED GA AS LASER,  
NOTING WAVEFORM CHARACTERISTICS  
A66-14974

RADIATION DAMAGE AND ANNEALING OF GALLIUM ARSENIDE  
LASER DIODE A66-14979

TEMPERATURE DEPENDENCE OF EMISSION SPECTRUM AND  
THRESHOLD CURRENT IN GA AS LASERS  
A66-17333

GALLIUM ARSENIDE LUMINESCENT DIODES WITH  
TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION  
AT HIGH DENSITY CURRENT A66-19195

SILICON AND SELENIUM DOPING EFFECTS ON GALLIUM  
ARSENIDE LASER CHARACTERISTICS A66-21879

GALLIUM ARSENIDE LASER EXCITATION BY FAST  
ELECTRONS A66-22146

CURRENT-VOLTAGE CHARACTERISTICS OF CW X-BAND  
GA AS MICROWAVE GUNN GENERATOR  
A66-23029

HOLE AND ELECTRON SMEARING AND P-TYPE ABSORPTION  
INFLUENCE ON THRESHOLD CURRENT A66-23478

PARAMETER DEPENDENCE OF INTERMEDIATE FREQUENCY  
VOLTAGE INDICATED DURING ESTABLISHMENT OF OPTIMUM  
CONDITIONS FOR OPTICAL RECEIVERS AND MERIT OF  
SUBCARRIER MIXING A66-23960

CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW  
A66-24011

OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER  
AS TRANSMITTER AND SILICON P-I-N PHOTODIODE AS  
DETECTOR USED AS AIRCRAFT ALTIMETER  
N66-11665

LIGHT EMISSION FROM GALLIUM ARSENIDE SEMICONDUCTOR  
P-N JUNCTION INJECTION LASER  
NOTS-TP-3655 N66-19703

ROOM TEMPERATURE OPERATION OF PULSED GALLIUM

ARSENIDE INJECTION LASER, AND IMPROVEMENT OF  
LASER DIODE STRUCTURE  
ECOM-01501-1 N66-20809

GALLIUM ARSENIDE LASER DIODES WITH HIGH OUTPUT  
COHERENT BEAM FOR COMMUNICATIONS SYSTEMS  
ECOM-2629 N66-21293

LASER MODULATOR USING GALLIUM ARSENIDE AND GALLIUM  
PHOSPHIDE ELECTRO-OPTIC CRYSTALS  
NASA-CR-71516 N66-21435

ZINC DIFFUSION IN GALLIUM ARSENIDE-PHOSPHIDE  
LASERS AND EFFECTS ON SEMICONDUCTOR JUNCTIONS  
AFCRL-66-18 N66-22611

GALLIUM COMPOUND  
SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION,  
CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION,  
FREQUENCY MODULATION LASERS, AND GALLIUM  
COMPOUND INGOTS FOR LASER APPLICATION  
AFCRL-64-1007 N65-23135

GALLIUM ARSENIDE ALLOY INGOT PREPARATION BY  
VAPOR TRANSPORT METHODS FOR LASER APPLICATIONS  
N65-23139

GALLIUM PHOSPHIDE  
DIRECT-INDIRECT TRANSITION EFFECT ON HALL EFFECT  
IN GALLIUM /ARSENIC PHOSPHIDE/ A66-21570

GALLIUM SELENIDE  
RADIATIVE RECOMBINATION WITH ELECTRON BEAM EXCITED  
CADMIUM TELLURIDE AND GALLIUM SELENIDE  
N66-12646

GAMMA RADIATION  
CO-60 GAMMA IRRADIATION INDUCED ENERGY OUTPUT  
INCREASE OF RUBY LASER CRYSTAL A65-17687

GAMMA RADIATION EFFECT ON ENERGY OUTPUT OF RUBY  
LASER CRYSTALS N65-17596

COMPTON SCATTERING OF LASER PHOTONS, NOTING  
TRANSFORMATION INTO GAMMA RADIATION PHOTONS UPON  
COLLISION WITH HIGH ENERGY ELECTRONS  
A66-17816

EFFECT OF RUBY LASER ENERGY ON GAMMA RADIATED  
HUMAN ADENOCARCINOMA CELLS  
SAM-TR-65-41 N66-11874

GARNET  
MICROWAVE PROPERTIES PARTICULARLY LINEWIDTH AND  
MAGNETIC ANISOTROPY IN CALCIUM-VANADIUM BISMUTH  
GARNET, NOTING TWM ISOLATOR A65-24964

GAS  
MECHANISMS ASSOCIATED WITH ELECTRICAL BREAKDOWN  
AND IONIZATION IN GAS CAUSED BY HIGH INTENSITY  
RUBY OR NEODYMIUM LASER ILLUMINATION  
D-920272-4 N66-11453

LASER-INDUCED NONLINEAR EFFECTS, RAMAN  
SCATTERING, AND GAS BREAKDOWN - SOVIET  
LITERATURE REVIEW  
ATD-P-65-74 N66-12270

LASER PHYSICS CONFERENCE - ENERGY EXCHANGE IN  
SOLIDS AND GASES, NONLINEAR EFFECTS, GAS  
BREAKDOWN, AND REFRACTIVE INDEX VARIATION  
AD-622507 N66-14573

GAS COMPOSITION  
OPTICAL PROPERTIES OF CHANGES IN GAS COMPOSITION  
IN DISCHARGE TUBE FOR HELIUM NEON LASER  
TR-64-257.10 N65-19952

GAS DENSITY  
INSTRUMENTATION TECHNIQUES FOR NEW TYPE OF GAS  
DENSITY MEASURING SYSTEM USING LIGHT SCATTERED  
FROM LASER BEAM AS MEASURED QUANTITY  
A66-15794

GAS DISCHARGE  
HIGH INTENSITY LOW VOLTAGE DISCHARGE RESULTING  
FROM RUBY LASER BEAM FOCUSING ON TITANIUM HYDRIDE  
TARGET A65-24282

- LASER BEAM-GAS INTERACTION INDUCED DISCHARGE STUDIED FOR THRESHOLD, BREAKDOWN AND EMITTED LIGHT CHARACTERISTICS A65-27084
- TIME-VARIATION AND SPONTANEOUS EMISSION FROM HE-HG DISCHARGE OF 6149 Å LASER TRANSITION A65-31451
- TEMPORAL DEPENDENCE IN LASER INDUCED GAS DISCHARGES REPT.-1935-2 N65-21555
- PINCH METHODS OF GAS DISCHARGE AS LIGHT SOURCE FOR OPTICAL PUMPING OF VARIOUS LASER MATERIALS N65-22742
- INTENSE LASER BEAM FOCUSING EFFECT IN GAS TO STUDY LIGHT-INDUCED DISCHARGES BY TIME-RESOLVED SPECTROSCOPY AND PHOTOGRAPHY A66-12978
- LASER OSCILLATIONS OF SILICON TETRACHLORIDE, SILICON TETRAFLUORIDE AND ETHYL SILICATE IN GASEOUS DISCHARGE A66-14973
- C W IR LASER OSCILLATION IN H BR AND HI GAS DISCHARGE A66-16756
- GAS DISCHARGE BY LASER PULSE, TAKING INTO ACCOUNT PHOTOIONIZATION DUE TO ELECTRON IMPACT A66-24887
- CONFERENCE ON PHYSICAL PROBLEMS OF QUANTUM ELECTRONICS - NONLINEAR OPTICAL PHENOMENA, SEMICONDUCTOR LASERS, GAS DISCHARGES IN GAS LASERS, AND GAS BREAKDOWN IN LASER BEAM JPRS-34262 N66-18135
- ENERGY LEVEL RELATIVE POPULATION DENSITIES OF NEON PLASMA USING HELIUM-NEON LASER - LANGMUIR PROBE ADDITIONS FOR MEASUREMENT OF PLASMA ELECTRON TEMPERATURE AND VELOCITY DISTRIBUTIONS ARL-65-246 N66-22488
- GAS DYNAMICS**
- LASER RESEARCH IN U.S.S.R., COMBUSTION INSTABILITY IN LIQUID ROCKET AND AIR BREATHING PROPULSION, GAS DYNAMICS AND PROPERTIES AT HIGH TEMPERATURE, AND MORPHOLOGICAL FORMS IN POLYMERS AD-460286 N65-23836
- GAS FLOW**
- CONTINUOUS WAVE GAS LASER DOPPLER FLOW METER FOR GAS VELOCITY MEASUREMENT N66-22338
- GAS HEATING**
- BREAKDOWN OF GASES UNDER INFLUENCE OF LASER SPARK PHENOMENA WITH SUBSEQUENT ABSORPTION OF LASER RADIATION AND GAS HEATING A66-10646
- GAS-ION INTERACTION**
- IONIZATION BREAKDOWN MECHANISMS OF GASES AT OPTICAL INFRARED FREQUENCIES USING LASERS RADC-TDR-64-422 N65-18624
- GAS LASER**
- MICROWAVE ELECTRON CYCLOTRON RESONANCE PUMPING OF NEON-HELIUM LASER TO RAISE PLASMA ELECTRON TEMPERATURE FOR INCREASE OF OUTPUT A65-15320
- GAS LASER CROSS MODULATION EFFECT WHEN EXPOSED TO FLASH TUBE RADIATION A65-15324
- MODE SUPPRESSION AND MODE STABILIZATION OF HELIUM-NEON LASER, USING TUNGSTEN WIRES AS MODE DISCRIMINATOR A65-15325
- ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS LASER WITH PLANE PARALLEL MIRRORS A65-15458
- BUILDUP AND DECAY TRANSIENT EFFECTS IN GAS LASERS DUE TO LIGHT ABSORPTION BY INSERTED LIQUID SAMPLES A65-15816
- FREQUENCY RESPONSE AND CROSS COUPLING OF RED AND IR GAS LASER INTERFEROMETER FOR MEASURING PLASMA ELECTRON DENSITY A65-15819
- GAS LASER MOLECULAR ABSORPTION DISCRIMINATION OF CLOSE FREQUENCIES A65-15998
- ABSORPTION OF 3.39 MICRON HELIUM-NEON LASER EMISSION BY METHANE IN ATMOSPHERE A65-16362
- INTERNAL MODULATION OF GAS LASER BY GERMANIUM PHOTODIODE INVERSELY POLARIZED AND MOUNTED IN COAXIAL CIRCUIT A65-16385
- FREQUENCY SPECTRA MEASUREMENT OF GASEOUS LASER BY PHOTOMIXING TECHNIQUES AND NOISE DISTRIBUTION A65-16405
- GAS LASER CONTINUOUS WAVE AMPLIFIER USING RECTANGULAR CROSS SECTION DISCHARGE TUBE, NOTING OPERATION AS CW OSCILLATOR AND PULSE AMPLIFIER A65-16406
- BROADBAND DIELECTRIC MIRRORS USED WITH PULSED GAS LASER TO OBSERVE LASER OSCILLATIONS IN VISIBLE WAVELENGTH REGION A65-16570
- MODE IMPURITY OBSERVED IN DIFFRACTION MEASUREMENTS EMPLOYING GAS LASER APPARENTLY RESONATING IN TEM-00 MODE A65-16571
- STIMULATED EMISSION OF ELECTROMAGNETIC WAVES FROM CIRCULAR CYLINDER AND SPHERE A65-17219
- XENON-KRYPTON LASER EMISSION IN 12 WAVELENGTHS RANGING FROM 2.03 TO 9 MICRONS WITH EXTERNAL AND INNER MIRRORS A65-17353
- OPTICAL CAVITY IN WHICH MODES ARE DETERMINED AS STATIONARY STATES OF DIFFRACTION-LIMITED OBJECT/ IMAGE TRANSFORMATION OF CLASSICAL OPTICS A65-18013
- OPTIMUM LASER EMISSION MODES RESULTING FROM HOLLOW CATHODE TUBE DISCHARGE DUE TO INELASTIC HELIUM-NEON ATOM COLLISIONS A65-18556
- LASER OPERATION MODES ARISING FROM METASTABLE NEON ATOM ANNIHILATION BY HYDROGEN AND OXYGEN MOLECULES A65-18557
- EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION A65-18558
- FAR IR GAS MASER OSCILLATOR DISCUSSING ENERGY LEVELS, PUMPING MOLECULAR RADIATION AND DETECTION A65-18849
- MICROWAVE AMPLIFICATION ACHIEVED IN SILICON DICDE EXHIBITING MICROPLASMA-FREE AVALANCHE MULTIPLICATION A65-19227
- VELOCITY MATCHED SECOND HARMONIC GENERATION / SHG/ AND MIXING OBTAINED IN PIEZOELECTRIC LITHIUM NIOBATE CRYSTALS A65-19235
- AMPLITUDE NOISE MEASUREMENT FOR CAVITY TYPE GASEOUS OPTICAL MASER OSCILLATOR ABOVE AND BELOW THRESHOLD A65-19544
- REQUIREMENTS FOR GENERATING TRULY CIRCULAR MODE OF OSCILLATION IN GAS LASER SYSTEM A65-19602
- HELIUM-NEON LASER RADIATION DISPERSION MEASUREMENT IN TRANSITION 3S2-2P4 FOR VARYING MIRROR SPACING A65-19693
- INEXPENSIVE SIMPLIFIED CONSTRUCTION OF DC POWERED HELIUM NEON LASER WITH 6328 Å OUTPUT A65-19849
- INTERFEROMETER EXPERIMENT OF HELIUM-NEON LASER SHOWS ITS RADIATION OBEYS LAWS OF CLASSICAL OPTICS A65-19994
- HE-NE LASER PROPERTIES AND LASER MECHANISM OF NE ATOMS, NOTING TRANSITION PROCESS AND OSCILLATION DYNAMICS A65-19999
- RECENT DEVELOPMENTS IN GAS LASERS WITH ATTENTION

# SUBJECT INDEX

## GAS LASER

TO INVERSION MECHANISMS, TWO AND THREE LEVEL  
COLLISION LASERS, ION LASERS AND CURRENTLY KNOWN  
TRANSITIONS A65-20060

MEASUREMENT OF GAS LASER RADIATIVE DECAY RATES AND  
TOTAL INELASTIC DESTRUCTIVE CROSS SECTION OF SHORT  
LIVED EXCITED STATES IN 4-NSEC TO 1000-NSEC RANGE  
A65-20061

GAS DISCHARGE COLLISION LASER EFFICIENCY AND POWER  
OUTPUT CONSIDERATIONS WITH ATTENTION TO MANGANESE  
AND LANTHANUM DISCHARGES A65-20062

ABSORPTION DATA FOR METHANE AND ETHANE, USING HE-  
NE TUNED LASER SPECTROSCOPY A65-20064

LASER OUTPUT OF XENON-HELIUM MIXTURE AS FUNCTION  
OF CHARGE DURATION, GAS PRESSURE AND TUBE DIAMETER  
A65-20063

SMALL STABLE HELIUM-NEON LASER CONSTRUCTION AND  
MODE PATTERNS A65-21256

AUTOMATIC FEEDBACK CONTROL FOR LONG-TERM FREQUENCY  
STABILIZATION OF HE- NE LASER AT CENTER  
FREQUENCY OF ATOMIC RESONANCE A65-21620

SINGLE-ATOM COHERENCE EFFECTS IN MEASUREMENT OF  
SPONTANEOUS EMISSION LINEWIDTHS IN HIGH-GAIN NEON  
LASER A65-21654

OPTICAL RESONATOR EFFECTS ON POPULATION  
DISTRIBUTION IN HELIUM-NEON GAS LASERS DETERMINED  
FROM SIDE LIGHT MEASUREMENTS A65-21656

NOBLE GAS-OXYGEN LASER OPERATION UNDER O13 TRIPLE  
P EXCITATION THROUGH COLLISION-INDUCED OXYGEN  
DISSOCIATION, NOTING BANDWIDTHS AND OSCILLATIONS  
A65-21810

PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J  
AND N TO K CALCULATED WITH GAS LASER A65-21811

CONTINUOUS OUTPUT GAS-PHASE LASERS AS SMALL  
BANDWIDTH SOURCES OF LIGHT FOR OPTICAL  
DIFFRACTOMETERS A65-22206

HE- NE GAS LASER APPLICATION TO SCHLIEREN  
PHOTOGRAPHY AND MACH- ZEHNDER INTERFEROMETRY IN  
AERODYNAMIC TESTING A65-22501

GAS MIXTURES AND PRESSURES FOR OPTIMUM OUTPUT  
POWER OF RF-EXCITED HELIUM-NEON GAS LASERS AT  
632.8 NM A65-22620

SIMPLE SINGLE MODE HELIUM-NEON LASER WHOSE OUTPUT  
IS SUFFICIENT FOR INTERFEROMETRIC METROLOGY  
A65-22621

VISIBLE AND UV LASER OSCILLATION AT 118  
WAVELENGTHS IN IONIZED NEON, ARGON, KRYPTON,  
XENON, OXYGEN AND OTHER GASES A65-22622

PULSED WATER VAPOR LASER FOR FAR IR GIVING DESIGN  
AND PERFORMANCE A65-22626

LASER PULSE GENERATION WITH PLASMA RESULTING FROM  
DISCHARGE IN HYDROGEN AS MEDIUM A65-22728

LASER OSCILLATION IN PULSED NOBLE-GAS-ION LASER AT  
NEAR- IR A65-22785

GAS LASER AS LIGHT SOURCE FOR MACH ZEHNDER  
INTERFEROMETER AS COMPARED TO MERCURY VAPOR LAMP  
A65-22949

CONTINUOUS GAS LASER BY DIRECT HF EXCITATION OF  
NITROUS OXIDE AND MIXTURE WITH ARGON IN CAVITY,  
NOTING PERFORMANCES A65-23273

GASEOUS OPTICAL MASERS CONSIDERING PROBLEM OF  
DOPPLER BROADENED TRANSITION SUBJECTED TO OPTICAL  
FREQUENCY FIELD IN STANDING WAVE FORM A65-24005

VISUAL PERCEPTION OF INTENSE COHERENT IR  
RADIATION FROM GAS LASER A65-24083

EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE  
OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE  
A65-24084

LASER TYPES AND THEIR APPLICATION IN RADAR,  
INSTRUMENTATION, NAVIGATION AND COMMUNICATIONS  
A65-24131

MODE LOCKING IN HELIUM-NEON LASER BY MEANS OF  
SYNCHRONOUS INTRACAVITY ACOUSTIC MODULATION IN  
COUPLED MULTIMODE CONFOCAL INTERFEROMETERS  
A65-24276

HELIUM-NEON LASER MULTIBEAM GENERATION IN GAS  
DISCHARGE TUBE, USING SPHERICAL MIRRORS AND  
TAPERED PLATES A65-24824

NOBLE GAS-OXYGEN LASER OPERATION UNDER O13  
TRIPLE P EXCITATION THROUGH COLLISION-INDUCED  
OXYGEN DISSOCIATION, NOTING BANDWIDTHS AND  
OSCILLATIONS A65-24862

PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J  
AND N TO K CALCULATED WITH GAS LASER A65-24863

DIFFRACTION LOSSES, PHASE SHIFTS AND FIELD  
DISTRIBUTION FUNCTIONS FOR TWO LOWEST-ORDER MODES  
ON INTERFEROMETER-TYPE MASER RESONATORS WITH  
CIRCULAR MIRRORS A65-24911

INTERFEROMETER USING SMALL DIFFRACTION GRATING AND  
GAS LASER LIGHT SOURCE IN SCHLIEREN SYSTEM FOR  
FLUID MECHANICS RESEARCH A65-25332

LASER WITH HOLLOW CATHODE DISCHARGE ON NEON-  
HYDROGEN MIXTURE AND CAVITY FORMED BY CYLINDRICAL  
MIRRORS A65-25590

HELIUM-NEON LASER OUTPUT DEPENDENCE ON HOLLOW  
CATHODE DISCHARGE CONDITIONS FOR ELECTRON  
TRANSITIONS IN NEON A65-25591

SYSTEM TRANSLATING FREQUENCY OF GAS LASER OVER  
RANGE OF SEVERAL GIGACYCLES, ELIMINATING NEED FOR  
ELECTRO-OPTIC CRYSTALS WITH CUBIC SYMMETRY  
A65-25872

LASER BEAM DEFLECTION MODULATION OBTAINED BY  
PASSING CURRENT THROUGH CADMIUM SULFIDE PRISM WITH  
OHMIC CONTACTS, USEFUL FOR THERMOCOUPLE MEASUREMENTS  
A65-25890

RESONANCE RADIATION TRAPPING BETWEEN LOWER LASER  
LEVEL AND ION GROUND STATE AS MECHANISM FOR  
QUENCHING AND RING-SHAPED BEAM FORMATION IN ION  
LASERS A65-26004

HELIUM-XENON AND KRYPTON-XENON GAS LASERS  
OPERATING IN FAR IR A65-26727

SINGLE-MODE SELECTION AND MODE VOLUME ENHANCEMENT  
IN HE- NE GAS LASER WITH INTERNAL LENS A65-26820

OUTPUT OF SINGLE MODE GAS LASER IN AXIAL MAGNETIC  
FIELD STUDIED FOR INCREASE IN FREQUENCY STABILITY  
A65-26954

INTERFEROMETER TUNING EFFECT ON ZEEMAN BEAT  
FREQUENCY IN RADIATION OF HELIUM-NEON LASER WITH  
APPLIED MAGNETIC FIELD A65-26956

OPTIMUM LASER EMISSION MODES RESULTING FROM HOLLOW  
CATHODE TUBE DISCHARGE DUE TO INELASTIC HELIUM  
NEON ATOM COLLISIONS A65-27149

LASER OPERATION MODES ARISING FROM METASTABLE  
NEON ATOM ANNIHILATION BY HYDROGEN AND OXYGEN  
MOLECULES A65-27150

EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR  
HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION  
A65-27151

U V ION LASER TRANSITIONS IN INERT GASES, OXYGEN  
AND NITROGEN BETWEEN 2300 AND 4000 ANGSTROMS,  
SHOWING RELATIONSHIP BETWEEN GAIN AND TUBE  
DIAMETER A65-27334



OPTICAL SECOND HARMONIC GENERATION ANGULAR  
VARIATION IN AMMONIUM DIHYDROGEN PHOSPHATE  
GAUSSIAN CW GAS LASER BEAM FOR NONLINEAR  
COEFFICIENT MEASUREMENTS A65-27724

PLASMA KINETIC PROCESSES IN NE- HE LASER LEADING  
TO POPULATION INVERSION A65-27738

BEAM DIVERGENCE ANGLE OF SINGLE TEM MODE NE- HE  
LASER OUTPUT AT 0.63 MICRONS A65-27739

ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS  
LASER WITH PLANE PARALLEL MIRRORS A65-28554

MIRROR HOLDER WITH DEFORMABLE HINGES GIVING  
CONSTANT HINGE LINES AT RIGHT ANGLES FOR GASEOUS  
AND SOLID STATE LASERS USE A65-28590

TIME DEVELOPMENT OF OUTPUT INTENSITY OF HE- NE  
LASER AFTER QUENCHING BY PUMPING PARTICLES INTO  
LOWER NEON LASER STATE A65-29075

PHOTOBLEACH CHARACTERISTICS BETWEEN TWO  
INDEPENDENTLY STABILIZED HE- NE LASERS A65-29117

FREQUENCY STABILIZATION OF DOUBLE MODE HELIUM-NEON  
LASER VIA PHASE LOCK CIRCUIT A65-29411

TRANSITION PROBABILITIES FOR AR II LASER LINES  
COMPARED WITH PREVIOUS THEORETICAL AND  
EXPERIMENTAL DATA A65-29799

ELECTRON DENSITY MEASUREMENTS IN PLASMA PRODUCED  
BY COMBINATION OF RF AND VERY FAST THETA-PINCH  
DISCHARGES, USING GAS LASER INTERFEROMETER A65-29848

TIME-DEPENDENT ELECTRON DENSITY VARIATION STUDIED  
IN FAST THETA-PINCH DISCHARGE, USING HE- NE GAS  
LASER INTERFEROMETER A65-29849

GAS CONSTITUTION OF HELIUM-NEON LASER DISCHARGE  
ANALYZED, CONSIDERING SPECTRUM LINE RELATIVE  
INTENSITIES IN LIGHT EMITTED FROM DISCHARGE TUBE A65-30333

LASER OSCILLATION IN GASEOUS IONS, TABULATION OF  
WAVELENGTHS, CLASSIFICATIONS AND REFERENCES FOR  
230 ION LASER TRANSITIONS A65-30343

ELECTRIC CIRCUIT ANALOG OPTIMUM DESIGN OF MODE-  
SELECTIVE MULTIREFLECTOR FABRY- PEROT LASER  
RESONATORS A65-30344

NOISE IN GAS LASERS AND LASER DETECTORS,  
AMPLIFIERS AND OSCILLATORS, NOTING HELIUM-NEON  
LASER OSCILLATION A65-31002

SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE  
LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-31306

HELIUM-NEON LASER OUTPUT CHARACTERISTICS AS  
FUNCTION OF LASER PARAMETERS A65-31375

LASER POWER DENSITY MEASURED WITH REDUCED  
ABSORPTION OF LIGHT BY METHYLENE BLUE, USING HE-  
NE- CW LASER A65-31455

DISPERSION OF 1.15 MICRON HE- NE LASER LINE  
RESULTING FROM NEON ABSORPTION TRANSITION A65-31762

LASER PULSE-SHAPING AND MODE-LOCKING WITH  
TRAVELING AND STATIONARY ACOUSTIC WAVES IN ARGON  
LASER A65-31763

PLASMA KINETIC PROCESSES IN NE- HE LASER LEADING  
TO POPULATION INVERSION A65-31843

BEAM DIVERGENCE ANGLE OF SINGLE TEM MODE NE- HE  
LASER OUTPUT AT 0.63 MICRONS A65-31844

PLASMA DECAY IN PULSE DISCHARGE OF HELIUM-NEON  
LASER GRAPHICALLY DEPICTED UNDER CONDITIONS OF  
GENERATION A65-31878

LASER CONFIGURATIONS, PERFORMANCE FEATURES AND  
LIMITATIONS DISCUSSING HE- NE, ION AND SOLID  
STATE LASERS A65-31881

GAS PRESSURE AND TUBE DIAMETER EFFECT ON OPTICAL  
GAIN OPERATING CHARACTERISTICS OF XENON LASER  
AMPLIFIER A65-32743

LASER BIBLIOGRAPHY / JUNE TO DECEMBER 1964/  
A65-32749

HE- NE GAS LASER OSCILLATING IN TWO LINEARLY  
POLARIZED MODES, COMPARING THEORETICAL AND  
EXPERIMENTAL MODE INTENSITIES AND BEAT FREQUENCIES A65-32844

MODULATION OF HELIUM-NEON LASER BY LIGHT FROM  
HELIUM DISCHARGE A65-33006

LASER BEAM AMPLIFICATION BY REFLECTION FROM  
SCANNING GAS LASER ACTIVE INTERFEROMETER A65-33047

LASER ACTION IN SECOND POSITIVE BAND SYSTEM OF  
MOLECULAR NITROGEN, OBSERVING SATURATION OF  
TRANSITION A65-33049

PULSED MOLECULAR NITROGEN LASER THEORY VIA  
ELECTRON IMPACT EXCITATION OF TRIPLET STATES A65-33050

CW HIGH POWER OPERATION OF NITROGEN-CARBON  
DIOXIDE LASER OSCILLATING ON P-BRANCH ROTATIONAL  
TRANSITIONS OF VIBRATIONAL BAND OF CARBON DIOXIDE A65-33055

LASER ACTION ON P- AND R-BRANCH TRANSITIONS OF  
CARBON DIOXIDE VIBRATIONAL SPECTRUM BAND PRODUCED  
BY PULSED DISCHARGE ADMIXTURE OF VARIOUS GASES A65-33058

SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE  
LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-33352

PULSE-DISCHARGE PLASMA DECAY STUDIED BY  
OBSERVATION OF GENERATION PROCESSES IN HELIUM-NEON  
PULSE LASER A65-33584

HOMOGENEITY AND DIFFUSION LENGTH OF MINORITY  
CARRIERS IN SEMICONDUCTORS MEASURED, USING LASER  
BEAM A65-33809

TWO BREWSTER-TYPE LASERS IN OSCILLATOR-AMPLIFIER  
CONFIGURATION USED TO MEASURE LASER GAIN IN  
XENON-KRYPTON DISCHARGE A65-34610

RELATION BETWEEN 600 ANGSTROM EMISSION BAND OF  
HELIUM MOLECULE AND IMPRISONMENT OF NEON RESONANCE  
LINES MEASURED TO SHOW EFFECT ON HELIUM-NEON LASER  
OPERATION A65-34662

ELECTRON DENSITY AND COLLISION FREQUENCY  
MEASUREMENTS IN TRANSIENT OSCILLATION OF IR AND  
VISIBLE HELIUM-NEON LASERS TO DETERMINE  
RELATIONSHIP BETWEEN OSCILLATIONS AND PLASMA  
PARAMETERS A65-34806

VISUAL PERCEPTION OF INTENSE COHERENT IR  
RADIATION FROM GAS LASER A65-34904

EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE  
OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE A65-34905

DESIGN AND CONSTRUCTION OF STABLE SINGLE FREQUENCY  
RF EXCITED HE- NE LASER AT 6328 ANGSTROMS A65-35358

GAS LASER EMISSION SOLUTION BY DETERMINING  
EMISSION FIELD DENSITY DEPENDENCE ON RESONATOR  
PARAMETERS, RELAXATION CHARACTERISTICS AND ATOM  
EXCITATION IN GAS DISCHARGE PLASMA A65-35868

HELIUM-NEON LASER MODULATION BY POSITIVE AND  
NEGATIVE VOLTAGE PULSES A65-35931

MODE DEGENERACY-DIPS ON OUTPUT OF HE- NE LASER

## SUBJECT INDEX

## GAS LASER CONT

- FOR CERTAIN CRITICAL COMBINATION OF MIRROR  
CURVATURES AND SEPARATION A65-36703
- RESONANT ENERGY TRANSFER FROM MERCURY TO ZINC IN  
GAS LASER AD-603680 N65-14200
- INFRARED SPECTRUM, OPTICAL PROPERTIES, AND  
FABRICATION OF EIGHT-METER GAS LASER  
NEL-1242 N65-14446
- EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASERS S-705 N65-15980
- GAS LASER OSCILLATOR AND SOLID STATE CHELATE LASER  
RADC-TDR-64-442 N65-16013
- GAS LASERS - LEVEL POPULATION DEPENDENCES, LASER  
POWER OUTPUT, METASTABLE DENSITY MEASUREMENTS,  
AND PARAMETER CHANGE EFFECT ON MATHEMATICAL  
MODEL OF LASER SYSTEM S-740 N65-20002
- PULSED GAS LASER FOR FAR INFRARED REGION OF  
SPECTRUM N65-20170
- SEPARATION OF SINGLE WAVE OSCILLATION MODES OF  
NEON-HELIUM GAS LASER N65-20782
- NEON-HELIUM GAS LASER APPLICATION TO SCHLIEREN  
PHOTOGRAPHY AND MACH-ZEHNDER INTERFEROMETRY  
FOR USE IN AERODYNAMIC TESTING N65-21372
- HELIUM-NEON GAS LASER DIRECT MODULATION  
N65-22300
- FOUR-LEVEL, GAS, LIQUID, SEMICONDUCTOR, AND RUBY  
LASERS RSIC-195 N65-24836
- CONTINUOUS WAVE GAS LASER AND HIGH SPEED MOTION  
PICTURE CAMERA FOR DETECTION OF NEARLY  
CONTINUOUS SET OF LIGHT SCATTERING PHOTOGRAPHS  
FROM POLYETHYLENE POLYMER SAMPLE  
ONR-TR-77 N65-25399
- HELIUM-NEON GAS LASER AS LIGHT SOURCE FOR MAGNETO-  
OPTICAL APPARATUS - KERR MAGNETO-OPTICAL EFFECT  
OF FERROMAGNETIC IRON-NICKEL THIN FILM N65-26766
- GAS LASER, EXTERNAL SHUTTER TRIGGER CONTROL,  
MEDIUM POWER LASER, Q-SWITCHING, AND AMPLIFIER  
FOR GEODETIC AND LUNAR SURVEYING  
AFCRL-65-196 N65-27084
- MULTIBEAM GENERATION OF GASEOUS HELIUM-NEON LASER  
N65-27252
- EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASER, XENON LIFETIMES, AND THEORY OF  
DIFFUSION CONTROLLED GLOW DISCHARGE S-669 N65-28779
- GASEOUS AND RUBY LASERS AS LIGHT SOURCES FOR  
PHOTOELASTICITY T&AM-276 N65-29794
- FREQUENCY STABILIZATION IN VISIBLE SPECTRUM OF  
GAS LASER USED AS OPTICAL PUMP GAIN MODULATOR  
NASA-CR-64359 N65-31013
- SPECTROSCOPY OF HIGH POWER GAS LASER EMISSION  
IN VISIBLE SPECTRUM FROM CW ARGON, KRYPTON,  
XENON, AND MERCURY-HELIUM LASERS  
QPR-3 N65-31202
- GAS LASER RANGE MEASUREMENT DEVICE GIVING HIGH  
ACCURACY DIFFERENTIAL TERRAIN HEIGHT INFORMATION  
FROM AIRBORNE PLATFORM N65-33571
- SODIUM-MERCURY METAL VAPOR LASER  
SP/PH/65-15 N65-33995
- USE OF LASERS FOR MEASUREMENT OF DISTANCE, ANGLE,  
HEIGHT, AND GEODETIC SURVEYING  
JPRS-32185 N65-34192
- ELECTRON ENERGY SPECTRA IN GAS LASER DISCHARGES  
AND INVESTIGATION OF NEW DISCHARGE  
CONFIGURATIONS NASA-CR-67298 N65-35355
- PEAK POWER TRANSIENTS OF NEAR CONFOCAL HELIUM-NEON  
LASER WORKING AT 6328 ANGSTROMS ON PULSED  
DISCHARGE BASIS A66-10329
- COHERENCE PROPERTIES OF HELIUM-NEON LASER WITH  
SUPERIMPOSED MODES EXAMINED BY INTERFERENCE  
PATTERN A66-10337
- SELF-LOCKED GAS LASER MODE DEPENDENCE ON CAVITY  
LENGTH AND POSITION OF LASER MEDIUM IN CAVITY  
A66-10347
- ELECTRON BEAM PUMPING OF NOBLE GAS ION LASER  
A66-10350
- LASER ACTION AT 5401 ANGSTROMS IN PURE NEON PULSED  
HIGH VOLTAGE DISCHARGE A66-10353
- LASER WITH DIFFRACTION LIMITED RADIATION PATTERN  
A66-10450
- CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER A66-10704
- PHASE RELATIONS OF LONGITUDINAL MODES IN GAS LASER  
WITH ANNULAR RESONATOR A66-10726
- ALUMINUM COLD CATHODES WITH SINGLE MODE  
6328 ANGSTROM HELIUM-NEON GAS LASER LIFETIMES  
EXCEEDING 3000 HOURS A66-10855
- GAS LASER INTERFEROMETERS FOR PLASMA LOW ELECTRON  
DENSITY MEASUREMENT A66-10856
- PLASMA RING DISCHARGE EXCITATION USED TO DRIVE  
HIGH CURRENT DENSITY ELECTRODELESS ARC FOR  
EXCITING GAS ION LASER TRANSITIONS A66-10967
- U V AND VISIBLE LASER OSCILLATIONS IN FLUORINE,  
PHOSPHORUS AND CHLORINE ATOMS IN PULSED CHLORINE,  
PHOSPHORUS FLUORIDE AND SULFUR FLUORIDE GAS  
DISCHARGES A66-10972
- RUBY CRYSTAL OPTICAL PROPERTIES INVESTIGATED BY  
INTERFERENCE RINGS FROM REFLECTING HE-NE LASER  
BEAM FROM CRYSTAL FACE A66-11045
- METALLIC PLASMA TUBE FOR ION LASERS ALLOWS THEM TO  
RUN AT HIGHER CURRENT DENSITIES THAN WITH CERAMIC  
TUBES A66-11373
- PRESSURE DEPENDENCE OF OUTPUT OF HELIUM-NEON  
GASEOUS LASER IN HIGH PRESSURE RANGE A66-11375
- LASER WITH HOLLOW CATHODE DISCHARGE ON NEON-  
HYDROGEN MIXTURE AND CAVITY FORMED BY CYLINDRICAL  
MIRRORS A66-11421
- HELIUM-NEON LASER OUTPUT DEPENDENCE ON HOLLOW  
CATHODE DISCHARGE CONDITIONS FOR ELECTRON  
TRANSITIONS IN NEON A66-11422
- LASER TRANSITION IN VIBRATIONAL STATE OF GROUND  
ELECTRONIC STATE OF CN FROM ROTATIONAL LEVEL 8 TO  
7 WITH POPULATION INVERSION AS RESULT A66-11451
- HELIUM-NEON LASER AMPLIFIER AS FUNCTION OF MIXTURE  
RATIO, GAS PRESSURE, INPUT SIGNAL LEVEL AND  
ELECTRICAL POWER INPUT TO AMPLIFIER TUBE A66-12206
- WIDTH OF DECAY QUANTA IN GAS LASERS DEPENDS ON  
ENERGIES AND LIFETIMES OF ATOMIC LEVELS INVOLVED  
IN STIMULATED TRANSITIONS AND NONLINEAR RESPONSE  
OF ATOMS A66-12303
- GAIN AND BANDWIDTH NARROWING IN REGENERATIVE  
HELIUM-XENON LASER AMPLIFIER A66-12308
- CURRENT DISCHARGE OF HELIUM NEON LASER ON LASER

- ACTION A66-12439
- LASER WITH DIFFRACTION LIMITED RADIATION PATTERN A66-13313
- MULTIREFLECTOR FABRY- PEROT LASER RESONATORS, DISCUSSING SUPPRESSION EFFECT AGAINST UNWANTED MODES A66-13325
- PERIODIC VARIATION OF QUALITY FACTOR OF HE- NE GAS LASER CAVITY BY VIBRATING QUARTZ-MODULATION OF LIGHT BEAM A66-13477
- EXCITATION AND INVERSION METHOD IN GAS LASERS NOTING CHARACTERISTICS OF HELIUM-NEON LASER AND IONIZED AND THREE-LEVEL LASER SYSTEM A66-13951
- EXPERIMENTS ON HELIUM-NEON FM LASERS COVERING PHASE-LOCKED AND FM REGION POWER OUTPUT, MODULATION INDEX AND DISTORTION EXPERIMENTS A66-13955
- HIGH POWER BREWSTER WINDOW LASER WITH GAS FILLS, DISCUSSING POWER OUTPUT AND EFFICIENCY PARAMETERS A66-13983
- C W GAS LASER, MEASURING VIBRATIONAL ROTATIONAL TRANSLATION FREQUENCIES OF CARBON MONOXIDE A66-13984
- STATIC CHARACTERISTICS OF GAS LASER INTERNAL MODULATION CIRCUIT, USING ELECTRO-OPTICAL CRYSTAL INSERTED INTO GAS LASER RESONATOR A66-14059
- RISE TIME AND OUTPUT POWER OF SINGLE PULSE IN HE- NE LASER MEASURED BY METHOD OF CHANGING Q-FACTOR BY PLATE LOCATED IN RESONANT CAVITY A66-14332
- SMALL PARTICLE DETECTION CAPABILITY OF LOW-GAIN HELIUM-NEON GAS LASER ENHANCED BY USE OF STOKES SETTLING LAW AND LAYERED SEDIMENTATION TECHNIQUE A66-14583
- HELIUM-NEON LASER OUTPUT CHARACTERISTICS AS FUNCTION OF LASER PARAMETERS A66-14897
- TRAVELING WAVE OSCILLATIONS OF ION RING LASER IN MIRROR-RING RESONATOR A66-14903
- TWO LENSES WITH FOCAL RATIOS OF F/4 AND F/2.65 USED TO COLLIMATE LIGHT FROM HELIUM-NEON LASER A66-14921
- MICROWAVE BEATS IDENTIFIED BETWEEN MODES IN BROMINE-ARGON MIXTURE A66-14923
- ELECTRODELESS EXCITATION OF DISCHARGE IN HELIUM-NEON GAS LASER TUBE APPLIED TO VOICE TRANSMISSION A66-14924
- C W LASER OSCILLATION BETWEEN 11.48 AND 11.55 MICRONS FROM NITROGEN-CARBON DISULFIDE SYSTEM A66-16384
- WAVELENGTH OF 3S2-2P4 TRANSITION OF NEON MEASURED, USING HELIUM-NEON LASER A66-16387
- HELIUM-NEON GAS LASERS, DISCUSSING AMPLITUDE VARIATION SUPPRESSION TECHNIQUE A66-16670
- C W HIGH-POWER CARBON DIOXIDE-NITROGEN-HELIUM LASER OPERATION, NOTING HELIUM ADDITION A66-16754
- GAS LASER OUTPUT AND THRESHOLD IN POPULATION INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE AND FLUORO IODO METHYLIDYNE A66-16771
- ADVANTAGES OF GAS LASERS AS LIGHT SOURCES IN AERODYNAMIC RESEARCH INTERFEROMETERS A66-16944
- INTERFERENCE PHENOMENON OF SERRATED SYSTEM OF RINGS SURROUNDING CENTRAL BEAM OF GAS LASER ANALYZED, USING HELIUM NEON TUBE PLACED BETWEEN TWO EXTERIOR MIRRORS A66-17064
- INTENSITY OF POLARIZED LIGHT TRANSMITTED THROUGH LASER AMPLIFIER AND LINEAR POLARIZER, AS FUNCTION OF AXIAL MAGNETIC FIELD STRENGTH A66-17292
- INTENSITY DISTRIBUTION OF FRINGE SYSTEMS USED TO VERIFY PHASE INVERSION BETWEEN TWO LOBES OF LASER IN TEM-10 MODE A66-17453
- ELECTRON ENERGY SPECTRA IN NEON, XENON AND HELIUM-NEON LASER DISCHARGES, CALCULATING PRODUCTION AND DESTRUCTION RATE PARAMETERS A66-18354
- GAS LASER DIRECT MODULATION A66-18355
- FREQUENCY STABILIZATION OF GAS LASERS, USING ATOMIC RESONANCE AND INTERFEROMETERS A66-18357
- BEAT FREQUENCIES AND COHERENCE PROPERTIES IN CIRCULARLY POLARIZED ATOMIC TRANSITIONS OF GASEOUS LASERS WITH AXIAL MAGNETIC FIELDS A66-18429
- BEAT FREQUENCY AND ROTATION OF POLARIZATION PLANE IN HE- NE LASER WITH AXIAL MAGNETIC FIELD A66-18430
- ANODE-CURRENT SPECTRUM OF PHOTOMULTIPLIER ILLUMINATED BY LIGHT OF TIME-VARYING INTENSITY AND CERIVATION OF MOMENTS OF PHOTOELECTRON COUNTS A66-18432
- HELIUM-NEON GAS DISCHARGE INTENSIFICATION FOR 6328 A LASER WAVELENGTH, DISCUSSING MEASUREMENT TECHNIQUES, GAIN PARAMETERS AND RESULTS A66-18632
- LASER DEVELOPMENT, DISCUSSING BASIC THEORY, PUMPING METHODS AND LASER TYPES A66-18700
- HIGHER ORDER CALCULATION OF LASER OUTPUT, NOTING APPROXIMATION METHOD FOR LINewidth PARAMETER AND LAMB DIP SHAPE ACCURACY A66-19063
- HELIUM-NEON GAS LASER USED IN RAMAN SPECTROSCOPY A66-19232
- GAS LASER EMISSION SOLUTION BY DETERMINING EMISSION FIELD DENSITY DEPENDENCE ON RESONATOR PARAMETERS, RELAXATION CHARACTERISTICS AND ATOM EXCITATION IN GAS DISCHARGE PLASMA A66-19271
- NONLINEAR ZEEMAN EFFECT FOR GAS LASER A66-19638
- MICROMACHINING WITH PULSED HELIUM-NEON GAS LASER, NOTING EXPERIMENTAL TECHNIQUES, OPERATION AND APPLICATION A66-19734
- ISOLATION OF 1.0621 LINE IN HE- NE GAS LASER BY MULTILAYER DIELECTRIC-COATED MIRRORS WITH SHARP SPECTRAL CUT-OFF CHARACTERISTICS A66-20517
- GAS LASER END REFLECTOR USING PELLIN- BROCA PRISM FOR SPECTRAL LINE SELECTION A66-20518
- ISOTOPE SHIFT MEASUREMENT FOR 6328 ANGSTROMS HELIUM-NEON LASER TRANSITION A66-21070
- OPTICAL SECOND HARMONIC GENERATION IN FOCUS OF LOWEST TRANSVERSE MODE OF CONTINUOUS WAVE GAUSSIAN GAS LASER BEAM A66-21175
- SIMULTANEOUS ACTION OF RF PERTURBATION BETWEEN ZEEMAN SUBLEVELS OF ATOMIC TRANSITION WHICH IS ALSO PRODUCING LASER OSCILLATION A66-21177
- LASER INDUCED GAS BREAKDOWN AT HIGH PRESSURES, NOTING EFFECT OF PLASMA DENSITY ON INDEX OF REFRACTION VIA OPTICAL FREQUENCY RESONANCE MEASUREMENT A66-21564

## SUBJECT INDEX

## GAS SPECTROSCOPY

C W LASER ACTION ON TRIPLE STATE PHOSPHORUS-SULFUR  
TRANSITION, USING HYDROGEN SULFIDE-NOBLE GAS  
MIXTURES A66-21577

MICROWAVE ANTENNA SIMULATION AT OPTICAL FREQUENCY,  
USING NEON-HELIUM CONTINUOUS GAS LASER A66-22539

ABSOLUTE WAVELENGTH STABILITY OF HELIUM-NEON LASER  
MEASURED BY DIRECT INTERFEROMETRIC COMPARISON WITH  
HG 198 STANDARD LAMP A66-22868

WAVELENGTH MEASUREMENT OF HELIUM-NEON LASER  
EMISSION BY DOUBLE-CHANNEL RECORDING  
INTERFEROMETER, USING KRYPTON-86 PRIMARY STANDARD  
A66-22874

DESIGN AND OPERATION OF HELIUM-NEON LASER NOTING  
RADIATION, FREQUENCY STRUCTURE, POWER DENSITY,  
EXTERNAL MAGNETIC FIELD EFFECT, APPLICATION, ETC  
A66-22980

MODE SUPPRESSION TECHNIQUES FOR GAS LASER SINGLE  
AXIAL MODE OPERATION FOR LARGE MIRROR SEPARATIONS  
A66-23093

RUBY CRYSTAL OPTICAL PROPERTIES INVESTIGATED BY  
INTERFERENCE RINGS FROM REFLECTING HE- NE LASER  
BEAM FROM CRYSTAL FACE A66-23292

CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER A66-23309

Q-SWITCHING OF CARBON DIOXIDE AND NITROUS OXIDE  
GAS LASER TRANSITIONS A66-23354

VIBRATIONAL AND ROTATIONAL RELAXATIONS IN CARBON  
DIOXIDE AND NITROUS OXIDE LASER SYSTEMS, USING Q-  
SWITCHING TECHNIQUES A66-23355

LASER ACTION ON ROTATIONAL LINE IN CARBON DIOXIDE  
AND NITROUS OXIDE VIBRATIONAL SPECTRA IN BOTH P  
AND R BRANCHES UP TO J VALUES OF OVER 50  
A66-23357

CONTINUOUS WAVE MEASUREMENT OF OPTICAL  
NONLINEARITY OF AMMONIUM DIHYDROGEN PHOSPHATE,  
USING HELIUM-NEON LASER A66-23716

POLISH-MADE HE- NE RED GAS LASERS, DESCRIBING  
POWER OUTPUTS, GAS PRESSURE, HE/ NE RATIO,  
MIRROR TRANSMISSION COEFFICIENT AND  
INTERFEROMETRIC APPLICATION A66-23946

BALANCED MIXER ACTION FOR OPTICAL HETERODYNING,  
USING MAGIC- T OPTICAL MIXER A66-24153

LONGITUDINAL MAGNETIC FIELD EFFECT UPON GAS  
DISCHARGE, ZEEMAN EFFECT AND FARADAY EFFECT IN  
HE- NE GAS LASER A66-24224

TWO-LEVEL ATOM INTERACTION WITH MULTIMODE GAS LASER  
CAVITY, OBTAINING STATIONARY STATE AND SOLVING  
UNIQUE EIGENVALUE IN SPECIAL CASES A66-24568

DEPENDENCE OF EMISSION INTENSITY OF GAS LASER ON  
LONGITUDINAL AND TRANSVERSE MAGNETIC FIELDS, USING  
SIMPLIFIED MODEL A66-24885

OPTIMUM DESIGN OF HIGH PRESSURE, LARGE DIAMETER,  
DIRECT NUCLEAR PUMPED, GAS LASERS  
ANL-7030 N66-11926

OPTICAL RADAR TECHNIQUES - STUDIES OF NEAR  
HEMISPHERICAL RESONATOR GAS LASER  
REPT.-1641-6 N66-12795

MATERIAL TESTING FOR GAS LASER OSCILLATOR AND  
SOLID STATE CHELATE LASER - OPTICAL RADARS  
RADC-TR-64-526 N66-12838

ARC-TUBE CONSTRUCTED FOR COOLING ARGON ION  
LASER - DISCHARGE TUBE  
GE/EE/65-1 N66-14188

LASER RESEARCH ACTIVITIES IN CHINESE PEOPLES  
REPUBLIC - FORMATION OF MICROWAVE MASER BY

LASER PUMPING, AND FORMATION TIME OF GAS LASER  
OSCILLATIONS  
JPRS-33323 N66-15048

DISPERSION EFFECTS IN LASER AMPLIFIERS  
AFOSR-65-2211 N66-16411

METASTABLE NITROGEN MOLECULES AS ACTIVE MEDIUM  
FOR TRANSFORMER LASER PUMPED BY BATTERY OF ND  
GLASS AUXILIARY LASERS  
GPL-A-31-2 N66-17001

CONFERENCE ON PHYSICAL PROBLEMS OF QUANTUM  
ELECTRONICS - NONLINEAR OPTICAL PHENOMENA,  
SEMICONDUCTOR LASERS, GAS DISCHARGES IN GAS  
LASERS, AND GAS BREAKDOWN IN LASER BEAM  
JPRS-34262 N66-18135

FRINGE COUNTING MICHELSON INTERFEROMETER USING  
HELIUM-NEON GAS LASER FOR INDUSTRIAL LENGTH  
MEASUREMENT  
SCL-DC-65-92 N66-20322

VISUAL PERCEPTION OF INFRARED LASER EMISSION  
NASA-TT-F-9888 N66-22300

CONTINUOUS WAVE GAS LASER DOPPLER FLOW METER FOR  
GAS VELOCITY MEASUREMENT N66-22338

ANGULAR DEPENDENCE OBSERVATIONS, ABSORPTION  
MEASUREMENTS, AND HIGH INTENSITY GAS LASER  
CONSTRUCTION IN STIMULATED RAMAN EMISSION AND  
ABSORPTION SPECTROSCOPY STUDY  
AD-626747 N66-23584

## GAS MASER

LIGHT OUTPUT FROM HELIUM-NEON GAS MASER  
PHOTOGRAPHED WITH AND WITHOUT INTRACAVITY  
MODULATION AT LOCKING FREQUENCY, USING HIGH SPEED  
ROTATING MIRROR A66-17205

PULSE EXCITATION OF VOLUME OF GAS TO COHERENTLY  
RADIATING STATE APPLIED TO BEAM MASER SPECTROMETER  
A66-23731

## GAS MIXTURE

LASER EXCITATION IN FREON AND RARE GAS MIXTURES  
BASED ON DISSOCIATIVE EXCITATION PROCESS AND  
QUENCHING ACTION OF SOME GASES A65-35043

OPTICAL MASER OUTPUT POWER AFFECTED BY GAS MIXTURE  
AND PRESSURE, RESONATOR GEOMETRY, AND MIRROR  
REFLECTIVITY FOR PLASMA RESEARCH  
N65-23495

TWO- AND THREE-STEP LASER CASCADES DETECTED  
EXPERIMENTALLY IN HELIUM-NEON MIXTURES, ANALYZING  
TWO-STEP CASCADE STARTING WITH DENSITY MATRIX  
FORMULATION A66-11477

HELIUM-NEON LASER AMPLIFIER AS FUNCTION OF MIXTURE  
RATIO, GAS PRESSURE, INPUT SIGNAL LEVEL AND  
ELECTRICAL POWER INPUT TO AMPLIFIER TUBE  
A66-12206

## GAS PHASE

VAPOR PHASE GROWTH OF RUBY SINGLE CRYSTALS FOR  
LASER APPLICATIONS  
AD-629154 N66-23875

## GAS PRESSURE

BACKGROUND GAS PRESSURE EFFECT ON LASER INDUCED  
ELECTRON EMISSION FROM ZINC AND TANTALUM SURFACES  
A65-15838

IONIZATION PHENOMENA IN ARGON DUE TO LASER  
RADIATION BY MEASURING ELECTRON DENSITY AND ENERGY  
AS TIME FUNCTION AFTER LASER PULSE INITIATION AT  
DIFFERENT GAS PRESSURES AND PREIONIZED CONDITIONS  
AIAA PAPER 66-176 A66-21690

## GAS SPECTROSCOPY

SPECTROSCOPY OF HIGH POWER GAS LASER EMISSION  
IN VISIBLE SPECTRUM FROM CW ARGON, KRYPTON,  
XENON, AND MERCURY-HELIUM LASERS  
CPR-3 N65-31202

GAS SPECTROSCOPY OF LASER-INDUCED STIMULATED  
BRILLOUIN EFFECT IN HIGH PRESSURE OXYGEN

- A66-23432
- GAS TUBE**  
OPTICAL PROPERTIES OF CHANGES IN GAS COMPOSITION  
IN DISCHARGE TUBE FOR HELIUM NEON LASER  
TR-64-257.10 N65-19952
- GASEOUS IONIZATION**  
IONIZATION BREAKDOWN MECHANISMS OF GASES AT  
OPTICAL INFRARED FREQUENCIES USING LASERS  
RADC-TDR-64-422 N65-18624
- GAS IONIZATION IN FOCUSED RUBY LASER BEAM  
N65-21219
- PLASMA PRODUCTION BY OPTICAL IRRADIATION OF GASES  
AND BY SOLIDS, CONSIDERING INTERACTION OF LASER  
RADIATION WITH SURFACES AND IRRADIATION OF  
PARTICLES OF SOLID MATERIAL IN VACUUM  
AIAA PAPER 66-174 A66-22212
- GEMINI PROJECT**  
LASER COMMUNICATION TRANSMITTERS FOR GT-7 GEMINI  
EXPERIMENTS  
NASA-CR-65246 N66-20941
- GENERATOR**  
SOLID-STATE LASER SYSTEM AS RADIATION PULSE  
GENERATOR  
STL-4127-6004-SU-000 N65-33686
- GEODESY**  
GEODETIC SATELLITE, CALIBRATION SATELLITE, LASER  
GEODESY, AIRBORNE GRAVITY METER, LUNAR MOTION  
AND GRAVITY, AND BALLOON-BORNE LUNAR PHOTOGRAPHS  
AFCRL-65-14 N65-22221
- GEODETIC SATELLITE**  
OPTICAL TRACKING OF SATELLITES EQUIPPED FOR  
GEODETIC TRIANGULATION, USING GROUND LASER BEAMS  
A65-29936
- GEODETIC SATELLITE, CALIBRATION SATELLITE, LASER  
GEODESY, AIRBORNE GRAVITY METER, LUNAR MOTION  
AND GRAVITY, AND BALLOON-BORNE LUNAR PHOTOGRAPHS  
AFCRL-65-14 N65-22221
- HIGH ENERGY LASER SYSTEM FOR LARGO GEODETIC  
SATELLITE OPTICAL TRACKING  
B-3011 N66-14591
- GEODETIC SURVEYING**  
GAS LASER, EXTERNAL SHUTTER TRIGGER CONTROL,  
MEDIUM POWER LASER, Q-SWITCHING, AND AMPLIFIER  
FOR GEODETIC AND LUNAR SURVEYING  
AFCRL-65-196 N65-27084
- USE OF LASERS FOR MEASUREMENT OF DISTANCE, ANGLE,  
HEIGHT, AND GEODETIC SURVEYING  
JPRS-32185 N65-34192
- GEOLOGY**  
RESEARCH IN CHINESE PEOPLES REPUBLIC - SOLAR  
FLUX, GAS DISCHARGE TUBE, NEODYMIUM LASER,  
GEOLOGICAL MECHANICS, MICROCRYSTALLINE GLASS,  
LOCATING OF THUNDER, AND PURIFICATION WITH  
DISTILLATION METHODS  
JPRS-33759 N66-16806
- GEOMETRICAL OPTICS**  
MICROWAVE RESEARCH ON ACOUSTIC WAVE AMPLIFICATIONS  
AND GEOMETRICAL OPTICS, OPTICAL MASERS,  
ELECTRON-PHONON INTERACTIONS, AND RAMAN  
SCATTERING FROM BIREFRINGENT CRYSTALS  
ML-1277 N65-20038
- ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASER,  
TUNABLE LASER, GEOMETRICAL OPTICS, SEMICONDUCTOR  
OSCILLATION, AND SOLID STATE PLASMA STUDIES FOR  
MICROWAVE TRANSMISSION  
ML-1316 N65-27969
- ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASERS,  
TUNABLE LASERS, ELECTRON-PROTON INTERACTIONS,  
SEMICONDUCTORS, GEOMETRIC OPTICS, AND SOLID  
STATE PLASMA STUDIES  
ML-1351 N65-34887
- BOOK ON MODERN OPTICS INCLUDING LASER AND COHERENT
- LIGHT, GEOMETRICAL OPTICS, LENS SYSTEMS,  
INSTRUMENTS, ETC A66-12623
- GERMANIUM**  
PHONON INTERACTION IN CRYSTALS - TRANSIENTLY  
OPERATED ACOUSTIC MASER, INTERACTION OF PHONONS  
WITH IMPURITIES IN GERMANIUM AND SILICON, AND  
HEAT PULSES IN CRYSTALS  
CTR-7 N65-27746
- BROADBAND TRAVELING WAVE MASER TECHNIQUES AND  
N-TYPE GERMANIUM SEMICONDUCTOR DEVELOPMENT  
RADC-TR-65-366 N66-15720
- GERMANIUM CHLORIDE**  
EPITAXIAL DEPOSITION OF GERMANIUM ON GALLIUM  
ARSENIDE BY HYDROGEN REDUCTION OF GERMANIUM  
TETRACHLORIDE - SEMICONDUCTOR AND LASER  
PRODUCTION  
SRRC-RR-65-52 N65-34688
- GERMANIUM RECTIFIER**  
INTERNAL MODULATION OF GAS LASER BY GERMANIUM  
PHOTODIODE INVERSELY POLARIZED AND MOUNTED IN  
COAXIAL CIRCUIT A65-16385
- GLASS**  
PREPARATION OF OPTICALLY HOMOGENEOUS LASER GLASS  
FREE OF PLATINUM INCLUSIONS BY PLATINUM  
PASSIVATION OR USING ALL-CERAMIC MELTING SYSTEM  
SATR-1 N65-22027
- SPECTRAL PUMPING EFFICIENCY, SOLARIZATION EFFECT,  
ENERGY OUTPUT, SPECTROSCOPY, GLASS DAMAGE AND  
OPTICAL PATH DISTORTIONS IN NEODYMIUM GLASS  
LASERS  
AD-612964 N65-24195
- EFFECT OF COMPOSITION ON THERMAL EXPANSION  
COEFFICIENT, THERMAL COEFFICIENT OF REFRACTIVE  
INDEX, BIREFRINGENCE, AND STRESS-OPTICAL  
COEFFICIENTS FOR ATHERMALIZING LASER GLASS  
TSR-5 N65-25688
- EFFECT OF LASER OPERATION PARAMETERS USING  
NEODYMIUM DOPED BORATE GLASS ON THRESHOLD AND  
OUTPUT ENERGY  
R-1748 N65-25782
- POLARIZATION OF LIGHT FROM GLASS LASER DOPED WITH  
TWO PERCENT POSITIVE TRIVALENT NEODYMIUM MEASURED  
WITH TIME RESOLUTION OF LESS THAN MICROSECOND  
A66-13006
- EFFECTS OF INTENSE ULTRAVIOLET RADIATION ON GLASS  
MATERIALS, AND PERFORMANCE CHARACTERISTICS OF  
GLASS LASERS  
AD-623309 N66-14533
- PREPARATION OF PLATINUM-FREE LASER GLASS  
SATR-2 N66-14672
- RESEARCH IN CHINESE PEOPLES REPUBLIC - SOLAR  
FLUX, GAS DISCHARGE TUBE, NEODYMIUM LASER,  
GEOLOGICAL MECHANICS, MICROCRYSTALLINE GLASS,  
LOCATING OF THUNDER, AND PURIFICATION WITH  
DISTILLATION METHODS  
JPRS-33759 N66-16806
- THERMAL OPTICAL DISTORTION MEASUREMENTS FOR  
NEODYMIUM DOPED GLASS LASER ROD  
MDE-6236 N66-22419
- GLASS COATING**  
NEODYMIUM DOPED LASER GLASS COMPARED ON BASIS OF  
FLUORESCENCE CHARACTERISTIC DIFFERENCES  
AD-612459 N65-25901
- GLASS FIBER**  
INTERFERENCE EFFECTS AT THIN TRANSPARENT  
CYLINDRICAL GLASS FIBERS EXPOSED TO COHERENT LIGHT  
FROM HE- NE LASER A66-10368
- GLASS FIBER LASERS FOR OPTICAL DATA PROCESSING  
AORC-4502-16-564-42 N66-11060
- GLOW DISCHARGE**  
EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASER, XENON LIFETIMES, AND THEORY OF

## SUBJECT INDEX

## HEAT TRANSFER

- DIFFUSION CONTROLLED GLOW DISCHARGE  
S-669 N65-28779
- GRAPHITE  
RUBY LASER PULSE TECHNIQUE APPLIED TO THERMAL  
DIFFUSIVITY MEASUREMENTS FOR TANTALUM AND  
GRAPHITE  
CONF-651020-1 N66-18228
- GROUND SPEED  
DOPPLER OPTICAL NAVIGATOR TO MEASURE  
INSTANTANEOUS GROUND SPEED WITH 0.1 FT/SEC  
ACCURACY FOR ALTITUDES OF 250 TO 5000 FEET -  
CONTINUOUS WAVE LASER AS TRANSMITTER  
TRG-019-1-2 N65-28160
- GROUND STATION  
RADIO STATION FACILITIES AT RAISTING, WEST  
GERMANY NOTING SATELLITE COMMUNICATION, MASER  
RECEIVING SYSTEM, PARABOLIC ANTENNAS, ETC  
A65-35195
- FACILITIES AND EQUIPMENT AT GOONHILLY DOWNS  
SATELLITE SYSTEM GROUND STATION - STEERABLE  
ANTENNA, COMPUTING AND DATA TRANSMISSION, AND  
HELIUM SYSTEM FOR MASER INSTALLATION  
N66-10260
- GUIDANCE SENSOR  
INERTIAL SENSORS REVIEWING RING LASER,  
ELECTROSTATIC FLUID SPHERE, MAGNETIC RESONANCE,  
SUPERCONDUCTIVITY GYROSCOPE, RELATIVISTIC ROTATING  
TENSOR, VORTEX RATE AND QUANTUM MECHANICAL EFFECT  
SENSING  
AIAA PAPER 65-401 A65-29669
- GUNNERY TRAINING  
PULSED LASER FOR SIMULATING TANK GUN FIRING FOR  
TRAINING OF TANK GUNNERS  
NAVTRADEVEN-1311-1 N65-34674
- H**
- HALIDE  
C W IR LASER OSCILLATION IN H BR AND HI GAS  
DISCHARGE A66-16756
- HALL EFFECT  
DIRECT-INDIRECT TRANSITION EFFECT ON HALL EFFECT  
IN GALLIUM /ARSENIC PHOSPHIDE/ A66-21570
- HAMILTONIAN  
EQUATIONS OBTAINED FROM HAMILTONIAN FOR COUPLING,  
FIRST STOKES LINE, FIRST ANTI-STOKES LINE AND  
COHERENT FIELD FOR RAMAN LASER  
A66-22490
- HARMONIC GENERATION  
SECOND HARMONIC GENERATION AND MEASUREMENT OF  
NONLINEAR POLARIZATION CONSTANT IN ADP, USING  
FOCUSED LASER BEAM A65-16672
- NONLINEAR OPTICAL EFFECTS IN CRYSTALLINE AND  
ISOTROPIC MATERIALS DUE TO INDUCED POLARIZATION  
THIRD ORDER IN ELECTRIC FIELD STRENGTH, USING  
GIANT PULSED LASER SOURCE A65-16863
- OPTICAL SECOND HARMONIC GENERATION APPLIED TO HIGH  
POWER COHERENT SOURCE FREQUENCY TRANSLATION IN  
COMMUNICATIONS SYSTEMS A65-19176
- VELOCITY MATCHED SECOND HARMONIC GENERATION / SHG/  
AND MIXING OBTAINED IN PIEZOELECTRIC LITHIUM  
NIOBATE CRYSTALS A65-19235
- SECOND HARMONIC LIGHT GENERATION IN CADMIUM  
SULFIDE CRYSTAL NEAR ABSORPTION BAND  
A65-21056
- ELECTROMAGNETIC FIELD AND SECOND OPTICAL HARMONIC  
GENERATED IN LASER RESONATOR AS TWO INTERDEPENDENT  
PROCESSES A65-25271
- OPTICAL SECOND HARMONIC GENERATION ANGULAR  
VARIATION IN AMMONIUM DIHYDROGEN PHOSPHATE  
GAUSSIAN CW GAS LASER BEAM FOR NONLINEAR  
COEFFICIENT MEASUREMENTS A65-27724
- SECOND HARMONIC EMISSION AND DIFFRACTION PHENOMENA
- IN KDP CRYSTAL EXCITED BY RUBY LASER BEAM  
A65-29559
- SECOND HARMONIC LIGHT GENERATION IN CADMIUM  
SULFIDE CRYSTAL NEAR ABSORPTION BAND  
A65-31220
- DOUBLE PHOTON ABSORPTION, HARMONIC GENERATION,  
AND FREQUENCY MIXING IN SEMICONDUCTORS, AND  
FREQUENCY TUNING OF INJECTION LASERS BY  
UNIAXIAL STRESS  
AD-450756 N65-14437
- OPTICAL PUMPING IN DARK RUBY, HARMONIC GENERATION  
IN HYDROGEN CYANIDE, SUBMILLIMETER WAVE  
SPECTROSCOPY, AND MIXING OF LASER LIGHT IN BULK  
PHOTOCONDUCTOR N65-26426
- SECOND HARMONIC LIGHT GENERATION, STRESSING  
SATURATION EFFECTS OCCURRING AT HIGH LASER POWER  
LEVELS, SOLVING NONLINEAR COUPLED MAXWELL  
EQUATIONS A66-11443
- POSSIBLE MATERIALS FOR SECOND HARMONIC GENERATION  
AND LASER ACTION DISCUSSING CENTROSYMMETRIC AND  
PIEZOELECTRIC CRYSTALS AND SINGLE CRYSTAL PLATE  
WITH ALTERNATE LAYERS OF NONCENTROSYMMETRIC  
COMPOSITION A66-12940
- CONTINUOUS OPTICAL SECOND-HARMONIC GENERATION  
USING ND/YAG LASER AND CRYSTAL OF SINGLE-DOMAIN  
LITHIUM NIOBATE A66-16378
- OPTICAL SECOND HARMONIC GENERATION IN FOCUS OF  
LOWEST TRANSVERSE MODE OF CONTINUOUS WAVE  
GAUSSIAN GAS LASER BEAM A66-21175
- SECOND HARMONIC GENERATION BY LASER BEAMS OF  
FINITE SPECTRAL WIDTH, USING QUANTUM TRANSITIONS  
AND KINETIC EQUATIONS, NOTING SHAPE OF PUMPING  
LINE AT FUNDAMENTAL FREQUENCY A66-22026
- CONTINUOUS WAVE MEASUREMENT OF OPTICAL  
NONLINEARITY OF AMMONIUM DIHYDROGEN PHOSPHATE,  
USING HELIUM-NEON LASER A66-23716
- CONSISTENT THEORY OF NONLINEAR OPTICAL EFFECTS IN  
BOUNDED LIGHT BEAMS BY EXTENDING PARABOLIC  
EQUATIONS TO NONLINEAR PROBLEMS A66-24888
- HARMONIC RADIATION  
NONLINEAR OPTICS IN MICROSCOPIC SEARCH FOR ORIGIN  
AND MACROSCOPIC STUDY OF LINKING BETWEEN INCIDENT  
RADIATION AND INDUCED RADIATION  
A65-36219
- HARMONICS  
LASER IRRADIATION ON SECOND OPTICAL HARMONICS  
FTD-TT-65-25/1 N65-29889
- HEAT DISSIPATION  
CONSTRUCTION PROBLEMS OF CONTINUOUS-DUTY DC  
EXCITED ION LASERS A66-13956
- HEAT SOURCE  
ELECTRON BEAM MELTING HEAT SOURCE IN VACUUM  
METALLURGY, AND RUBY AND NEODYMIUM GLASS LASERS  
FOR INDUSTRY N65-23723
- HEAT TRANSFER  
ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN  
ENERGY ABSORPTION AND POPULATION INVERSION  
A65-36055
- AERODYNAMIC AND HEAT TRANSFER MEASUREMENTS USING  
INTERFEROMETER WITH CONTINUOUS WAVE LASER AS  
SOURCE A66-10849
- HEATING PROCESS IN LASER WELDING OF METAL SHEETS,  
TAKING INTO ACCOUNT ENERGY DISTRIBUTION, HEAT  
TRANSFER AND FLUX DENSITIES A66-15347
- ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN  
ENERGY ABSORPTION AND POPULATION INVERSION  
A66-15858

## HEATING EQUIPMENT

## SUBJECT INDEX

- HEATING EQUIPMENT**  
HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A65-35877
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A66-18972
- HEISENBERG THEORY**  
SOLID STATE LASER SYSTEM, DESCRIBING QUANTUM  
MECHANICAL TREATMENT OF SELF-SUSTAINED OSCILLATION  
FOR ONE MODE  
A66-17817
- HELIUM**  
EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASERS  
S-705  
N65-15980
- RADIATION PROTECTIVE DRUGS, XENON AND HELIUM-  
XENON LASERS, HELIUM-NEON LASER WITH SILVER AND  
DIELECTRIC COATINGS, AND TRANSISTOR CIRCUITS  
JPRS-29200  
N65-20134
- STIMULATED EMISSION OF LIGHT FROM PURE XENON AND  
HELIUM-XENON  
N65-20135
- HELIUM-NEON LASER WITH SILVER AND DIELECTRIC  
COATING  
N65-20136
- SEPARATION OF SINGLE WAVE OSCILLATION MODES OF  
NEON-HELIUM GAS LASER  
N65-20782
- HELIUM-NEON GAS LASER DIRECT MODULATION  
N65-22300
- RADIATION DIVERGENCE MEASUREMENT IN HELIUM-NEON  
LASERS WITH CONFOCAL RESONATORS AND SPHERICAL  
REFLECTORS  
N65-24550
- STUDY OF PARAMETERS OF HIGH GAIN 2.026 MICRON  
XENON-HELIUM LASER TO OPTIMIZE POWER OUTPUT  
AND EFFECT OF TUBE DIAMETER ON SMALL SIGNAL GAIN  
WRE-PAD-104  
N65-28901
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW  
A66-11190
- C W LASER ACTION IN CARBON DIOXIDE-HELIUM MIXTURES  
A66-16385
- LIGHT OUTPUT FROM HELIUM-NEON GAS MASER  
PHOTOGRAPHED WITH AND WITHOUT INTRACAVITY  
MODULATION AT LOCKING FREQUENCY, USING HIGH SPEED  
ROTATING MIRROR  
A66-17205
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW  
A66-24011
- HELIUM-NEON LASER WITH HIGH SPECIFIC POWER FOR  
USE WITH OPTICAL TRACKING SYSTEMS AT 6328 Å  
NASA-CR-68589  
N66-13349
- HELIUM AFTERGLOW**  
RELATION BETWEEN 600 Å EMISSION BAND OF  
HELIUM MOLECULE AND IMPRISONMENT OF NEON RESONANCE  
LINES MEASURED TO SHOW EFFECT ON HELIUM-NEON LASER  
OPERATION  
A65-34662
- HELIUM COMPOUND**  
HELIUM-NEON LASER AMPLIFIER AS FUNCTION OF MIXTURE  
RATIO, GAS PRESSURE, INPUT SIGNAL LEVEL AND  
ELECTRICAL POWER INPUT TO AMPLIFIER TUBE  
A66-12206
- HELIUM PLASMA**  
THOMSON SCATTERED LASER RADIATION USED TO  
DETERMINE ELECTRON DENSITY IN HELIUM PLASMA,  
EXAMINING THYRATRON TUBE AND VOLTAGE PROBE USE  
A65-19618
- NOISE IN GAS LASERS AND LASER DETECTORS,  
AMPLIFIERS AND OSCILLATORS, NOTING HELIUM-NEON  
LASER OSCILLATION  
A65-31002
- TIME-VARIATION AND SPONTANEOUS EMISSION FROM HE-  
HG DISCHARGE OF 6149 Å LASER TRANSITION  
A65-31451
- MODULATION OF HELIUM-NEON LASER BY LIGHT FROM  
HELIUM DISCHARGE  
A65-33006
- MULTIBEAM GENERATION OF GASEOUS HELIUM-NEON LASER  
N65-27252
- CURRENT DISCHARGE OF HELIUM NEON LASER ON LASER  
ACTION  
A66-12439
- HENISPHERE**  
OPTICAL RADAR TECHNIQUES - STUDIES OF NEAR  
HEMISPHERICAL RESONATOR GAS LASER  
REPT.-1641-6  
N66-12795
- HEMOGLOBIN**  
RETINAL VASCULATURE OF RABBIT AND MONKEY AS  
AFFECTED BY LASER IRRADIATION PROXIMITY OF  
PIGMENT EPITHELIUM, BLOOD FLOW, AND AMOUNT OF  
REDUCED HEMOGLOBIN  
A66-80470
- HIGH ENERGY ELECTRON**  
GIANT PULSE LASER USED FOR PRODUCTION OF PARTICLES  
WITH ENERGIES HIGHER THAN TEN BILLION EV  
A65-25877
- HIGH FREQUENCY**  
LINEAR COEFFICIENT OF AMPLIFICATION OF CARBON  
DIOXIDE SUBJECTED TO HF EXCITATION FIELD FOR  
LASER EMISSION  
A66-12003
- HIGH POWER PROJECT**  
HIGH POWER GALLIUM-ARSENIC INJECTION LASER DIODES  
AD-621649  
N66-13744
- HIGH SPEED CAMERA**  
ELECTROSTATIC IMAGE CONVERTER CAMERA USED IN  
PLASMA AND LASER RESEARCH FOR HIGH SPEED WRITING  
A65-32585
- CONTINUOUS WAVE GAS LASER AND HIGH SPEED MOTION  
PICTURE CAMERA FOR DETECTION OF NEARLY  
CONTINUOUS SET OF LIGHT SCATTERING PHOTOGRAPHS  
FROM POLYETHYLENE POLYMER SAMPLE  
ONR-TR-77  
N65-25399
- LASER TECHNIQUE TO PHOTOGRAPH HYPERVELOCITY  
PROJECTILES IN FREE-FLIGHT RANGE  
A66-13248
- HIGH STRENGTH STEEL**  
LIFT SUPPORT SYSTEM, FLUID AMPLIFICATION,  
SPALLING, COMMUNICATIONS SATELLITE, MICROWAVE  
APPARATUS, HIGH STRENGTH STEEL, TRACERS, LASERS,  
ATMOSPHERIC TURBULENCE, AND RESONANCE  
AD-611432  
N65-22732
- HIGH TEMPERATURE PLASMA**  
DENSE HIGH-TEMPERATURE HYDROGEN PLASMA PRODUCTION  
BY INTENSE LASER PULSE HEATING OF MAGNETICALLY  
CONTAINED PLASMA  
A65-29978
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A65-35877
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A66-18972
- INFRARED MASER INTERFEROMETRY FOR TIME AND SPACE  
RESOLUTION OF ELECTRON DENSITY IN HIGH  
TEMPERATURE PLASMAS  
ARL-65-135  
N66-20024
- HOLMIUM**  
LASER CHARACTERISTICS OF AND COHERENT OSCILLATIONS  
FROM TRIVALENT TM, HO, YB AND ER IONS IN  
YTTRIUM ALUMINUM GARNET  
A66-10241
- HOLOGRAPHY**  
LENSELESS PHOTOGRAPHY USING LASERS AND HOLOGRAM/  
INTERFERENCE PATTERNS BETWEEN REFERENCE WAVE AND  
WAVES SCATTERED BY RECORDED OBJECT/PRODUCING  
THREE-DIMENSIONAL IMAGES  
A65-27196
- COHERENT LASER LIGHT USED IN NEW PHOTOGRAPHIC  
PROCESS FOR RECORDING LIGHT WAVES INSTEAD OF IMAGE

# SUBJECT INDEX

# IMAGE CONVERTER

- ON LIGHT-SENSITIVE FILM A65-28104
- HIGH SPEED PHENOMENA HOLOGRAMS PRODUCED BY RADIATION FROM PULSED RUBY LASER OPERATED EITHER IN Q-SWITCHED OR CONVENTIONAL MODE A65-35067
- LASER APPLICATION PROBLEMS IN INTERFEROMETRY, RADAR AND HOLOGRAPHY INCLUDING MECHANICAL STABILITY, NOISE SUPPRESSION, DIRTY LASER BEAM RESTORATION, ETC A66-11454
- OPTICAL DATA PROCESSING TECHNIQUES CONSIDERING STORAGE, MANIPULATION, HOLOGRAPHY AND PATTERN RECOGNITION USING MATCHED FILTERS A66-12997
- LASER APPLICATION IN PHOTOGRAPHY, NOTING INTERFEROMETRIC AND HOLOGRAPHIC TECHNIQUES A66-21333
- TWO-BEAM INTERFEROMETRY BY WAVEFRONT RECONSTRUCTION FROM HOLOGRAM RECORDED WITH COHERENT BACKGROUND SUCCESSIVELY INTERFERE IN SAME LATENT IMAGE A66-23204
- HOMODYNE  
COHERENT INTERFERENCE REJECTION, DISCUSSING NOISE AND MODULATOR-LEAKAGE PICKUP REJECTION IN LASER COMMUNICATIONS EXPERIMENTS A66-17217
- HOMOGENEITY  
RUBY-LASER ROD HOMOGENEITY DETERMINATION BY INTERFEROMETERS A65-19569
- HUMAN  
EFFECT OF RUBY LASER ENERGY ON GAMMA RADIATED HUMAN ADENOCARCINOMA CELLS SAM-TR-65-41 N66-11874
- HUMAN PATHOLOGY  
STUDIES ON RADIATION PROTECTION FOR MAN, OPTICAL MASER OF NEODYMIUM IN TUNGSTATE, CYLINDER WAVE PROPAGATION ANALYSIS, AND ELECTROMOTIVE FORCE OF INDIUM ANTIMONIDE COMPOUND JPRS-33152 N66-15042
- HUMIDITY MEASUREMENT  
MEASUREMENT OF VERTICAL WATER VAPOR PROFILES BY MEANS OF THERMALLY TUNED RUBY LASER OPTICAL RADAR SYSTEM - HUMIDITY MEASUREMENT REPT.-65-6 N66-14852
- HYDROACOUSTICS  
EFFICIENT DIFFRACTION OF INCIDENT LASER BEAM AT BRAGG ANGLE INCIDENCE INTO FIRST-ORDER MODE, USING TRAVELING ULTRASONIC WAVES IN WATER A65-33057
- HYDRODYNAMICS  
RUBY LASER HIGH SPEED PHOTOGRAPHY OF CAVITATION DAMAGE TO SOLIDS DUE TO HIGH SPEED JETS FROM COLLAPSING BUBBLES E-115.1 N66-21887
- HYDROGEN  
EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE A65-24084
- HYDROGEN MASER CONSTRUCTION AND OPERATION DESIGN PRINCIPLES EMPHASIZING MICROWAVE CAVITY, LOW MAGNETIC FIELD, HYDROGEN STORAGE AND MASER TUNING TECHNIQUES A65-24309
- HYDROGEN MASER RESETTABILITY VERIFYING BY MEASURING MASER OUTPUT FREQUENCY AGAINST HYDROGEN PRESSURE, CONSIDERING EXCHANGE COLLISION AND WALL INTERACTIONS A65-29119
- EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE A65-34905
- MULTICAVITY RADIOMETER MASERS FOR RECORDING 21 CM EMISSION FROM GALACTIC HYDROGEN N65-18885
- POWER AND PATH LENGTH EFFECTS ON STIMULATED RAMAN SPECTRA IN METHANE AND HYDROGEN STUDIES USING GIANT PULSED LASER N66-20037
- COMPARISON OF HYDROGEN MASER AND OF CESIUM BEAM TUBE FREQUENCY STANDARD NASA-TN-D-3292 N66-21698
- HYDROGEN ATOM  
ATOMIC HYDROGEN MASER FOR MEASURING RF AND MICROWAVE SPECTRAL LINES DISCUSSING THRESHOLD, RELAXATION, FREQUENCY STABILITY AND HYPERFINE STRUCTURE A65-26934
- SEPARATION AND FOCUSING OF ATOMIC BEAMS FOR ATOMIC HYDROGEN MASERS N65-26679
- VARIATION OF SCATTERING CROSS SECTION WITH BEAM INTENSITY FOR RUBY LASER LIGHT ON ATOMIC HYDROGEN A66-15864
- CROSS CORRELATION MEASUREMENTS OF OSCILLATOR FREQUENCY STABILITY AND THERMAL NOISE AND APPLICATION TO ATOMIC HYDROGEN MASER A66-24128
- HYDROGEN COMPOUND  
C W IR LASER OSCILLATION IN H BR AND HI GAS DISCHARGE A66-16756
- HYDROGEN ION  
HYDROGEN MOLECULE MULTIPHOTON IONIZATION, DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY RUBY LASER EMISSION A66-16517
- HYDROGEN MOLECULE MULTIPHOTON IONIZATION, DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY RUBY LASER EMISSION A66-20898
- HYDROGEN PLASMA  
THOMSON SCATTERING SPECTRUM OF LASER BEAM FROM EQUILIBRIUM HYDROGEN PLASMA, NOTING EFFECT OF DEBYE LENGTH A65-17151
- DENSE HIGH-TEMPERATURE HYDROGEN PLASMA PRODUCTION BY INTENSE LASER PULSE HEATING OF MAGNETICALLY CONTAINED PLASMA A65-29978
- HYPERFINE STRUCTURE  
ATOMIC HYDROGEN MASER FOR MEASURING RF AND MICROWAVE SPECTRAL LINES DISCUSSING THRESHOLD, RELAXATION, FREQUENCY STABILITY AND HYPERFINE STRUCTURE A65-26934
- HYPERSONICS  
STIMULATED BRILLOUIN SCATTERING OF INTENSE LASER LIGHT WITH BUILD-UP OF COHERENT HYPERSONIC WAVES IN LIQUIDS NASA-CR-58214 N65-33710
- BRILLOUIN SCATTERING IN LIQUIDS EXAMINING VELOCITY, FREQUENCY AND LIFETIME OF THERMALLY EXCITED HYPERSONIC SOUND WAVES, USING LASER LIGHT SOURCES A66-12422
- HYPERVELOCITY PROJECTILE  
LASER TECHNIQUE TO PHOTOGRAPH HYPERVELOCITY PROJECTILES IN FREE-FLIGHT RANGE A66-13248
- ILLUMINATION  
RUBY LASER WITH CONCENTRIC RESONATOR AS ILLUMINATION SOURCE OF BUBBLE CHAMBER A66-11189
- RUBY LASER WITH CONCENTRIC RESONATOR AS ILLUMINATION SOURCE OF BUBBLE CHAMBER A66-24010
- MECHANISMS ASSOCIATED WITH ELECTRICAL BREAKDOWN AND IONIZATION IN GAS CAUSED BY HIGH INTENSITY RUBY OR NEODYMIUM LASER ILLUMINATION C-920272-4 N66-11453
- IMAGE CONVERTER  
ELECTROSTATIC IMAGE CONVERTER CAMERA USED IN PLASMA AND LASER RESEARCH FOR HIGH SPEED WRITING A65-32585



# IMAGE FILTER

## IMAGE FILTER

COHERENT TRANSFER CHARACTERISTICS OF OPTICAL SYSTEM, HOLOGRAMS AND COMPLEX SPATIAL FILTERS, AND LASER APPLICATIONS  
D-5210-72-T80-110  
N65-21691

## IMAGE TRANSDUCER

ELECTRO-OPTICS CONTRIBUTIONS TO OPTICAL ASTRONOMY, IMAGE TRANSDUCERS, AND LASER RESEARCH AND EFFECT ON CIVILIAN TECHNOLOGY  
N66-17721

## IMAGING TECHNIQUE

OPTICAL CAVITY IN WHICH MODES ARE DETERMINED AS STATIONARY STATES OF DIFFRACTION-LIMITED OBJECT/ IMAGE TRANSFORMATION OF CLASSICAL OPTICS  
A65-18013

CONJUGATE-CONCENTRIC LASER RESONATOR WITH SIMPLE IMAGING SYSTEM GEOMETRY DISCUSSING PROPERTIES, EIGENVALUE PROBLEM AND FILTERING FUNCTIONS  
A65-18206

GIANT PULSED LASER TO ILLUMINATE DISTANT TARGET WITH LIGHT PULSE OF ABOUT 60 NANoseconds  
A65-24781

IMAGE FORMING IN ATMOSPHERIC SCATTERING MEDIUM WITH 60 NANoseCOND ILLUMINATING PULSE FROM Q-SWITCHED RUBY LASER  
AFAL-TR-64-278  
N65-25580

## IMPACT PRESSURE

INTERACTION OF LIGHT PULSE FROM RUBY LASER WITH MERCURY SURFACE, OBSERVING MECHANICAL IMPACT BELIEVED TO BE RAPID VAPORIZATION PROCESS  
A66-14373

## IMPURITY

SOLID STATE LASERS WITH EMPHASIS ON PUMPING MECHANISMS, SEMICONDUCTOR DEVICES AND IMPURITY-MATRIX SYSTEMS  
A65-24007

KINETIC EQUATION THEORY APPLIED TO STEADY STATE LASER RADIATION DUE TO BAND-BAND TRANSITION IN SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS  
A65-26694

KINETIC EQUATION THEORY APPLIED TO STEADY STATE LASER RADIATION DUE TO BAND-BAND TRANSITION IN SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS  
A65-32952

LASER MODE OPERATION IN PRESENCE OF RADIATION ABSORBING IMPURITY ANALYZED BY EXTENDED THOMSON TYPE SYSTEM  
A65-35930

## INCIDENT RAY

GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM INCIDENT ON PLANE PARALLEL GLASS PLATE OF RESONATOR  
A65-18555

GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM INCIDENT ON PLANE PARALLEL GLASS PLATE OF RESONATOR  
A65-27148

## INDICATOR

EVALUATION OF MASER-EQUIPPED WEATHER RADAR SET AND AREA-PRECIPITATION MEASUREMENT INDICATOR - METEOROLOGICAL SENSING DEVICE - ELECTRONICS  
QPR-1  
N66-14191

MASER EQUIPPED WEATHER RADAR AND PRECIPITATION MEASUREMENT INDICATOR  
QPR-2  
N66-19957

## INDIUM ANTIMONIDE

IN SB LONGITUDINAL INJECTION-PLASMA LASER, NOTING PLASMA PINCH AND MODE STRUCTURE  
A65-17210

EFFECTIVE MASS IN IN AS AND IN SB FROM LANDAU SHIFT OF PEAK EMISSION IN LASER DIODES  
A66-21579

STUDIES ON RADIATION PROTECTION FOR MAN, OPTICAL MASER OF NEODYMIUM IN TUNGSTATE, CYLINDER WAVE PROPAGATION ANALYSIS, AND ELECTROMOTIVE FORCE OF INDIUM ANTIMONIDE COMPOUND  
JPRS-33152  
N66-15042

# SUBJECT INDEX

## INDIUM ARSENIDE

INDIUM ARSENIDE DIODE SPONTANEOUS AND LASER ELECTROLUMINESCENCE IN MAGNETIC FIELDS  
A65-24961

STIMULATED EMISSION IN INDIUM ARSENIDE SHOWS EXCITATION THRESHOLD LOW AND LIGHT EMISSION HIGHLY DIRECTIONAL  
A66-17026

EFFECTIVE MASS IN IN AS AND IN SB FROM LANDAU SHIFT OF PEAK EMISSION IN LASER DIODES  
A66-21579

CARBON AND ETHYLENE TETRACHLORIDE ULTRASONIC MODULATORS APPLIED TO IR LASER HETERODYNE EXPERIMENTS ON IN AS PHOTODIODE  
A66-23353

## INDUSTRY

RUBY AND NEODYMIUM GLASS LASERS FOR INDUSTRY - ELECTRONICS  
N65-23722

COMMUNIST CHINA RESEARCH ON LIQUID, SOLID, GAS, PLASTIC, GLASS, AND INJECTION LASERS - APPLICATIONS IN MEDICINE, INDUSTRY, AND DEFENSE  
JPRS-33257  
N66-14355

ELECTRO-OPTICS CONTRIBUTIONS TO OPTICAL ASTRONOMY, IMAGE TRANSDUCERS, AND LASER RESEARCH AND EFFECT ON CIVILIAN TECHNOLOGY  
N66-17721

## INERTIAL ACCELEROMETER

INERTIAL SENSORS REVIEWING RING LASER, ELECTROSTATIC FLUID SPHERE, MAGNETIC RESONANCE, SUPERCONDUCTIVITY GYROSCOPE, RELATIVISTIC ROTATING TENSOR, VORTEX RATE AND QUANTUM MECHANICAL EFFECT SENSING  
AIAA PAPER 65-401  
A65-29669

## INFORMATION

PHYSICAL ELECTRONICS, SOLID STATE PHYSICS, LIQUID STATE PHYSICS, INFORMATION SCIENCES, AND LASER AND COMMUNICATION THEORY  
LMSC-6-75-65-10  
N65-25125

## INFRARED MASER

IR LASER ACTION IN ARGON II BETWEEN 1 AND 2 MICRONS AND IN 6000 TO 7000 ANGSTROM RANGE  
A65-17207

EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION  
A65-18558

HELIUM-NEON LASER PREAMPLIFIER SYSTEM FOR VERY HIGH GAIN TRANSITION AT 3.39 MICRON WAVELENGTH  
A65-21335

PULSED WATER VAPOR LASER FOR FAR IR GIVING DESIGN AND PERFORMANCE  
A65-22626

LASER OSCILLATION IN PULSED NOBLE-GAS-ION LASER AT NEAR-IR  
A65-22785

VISUAL PERCEPTION OF INTENSE COHERENT IR RADIATION FROM GAS LASER  
A65-24083

REFRACTIVE INDEX OF SOLID DETERMINED, USING FAR IR MICHELSON INTERFEROMETER ILLUMINATED WITH RADIATION FROM CN MASER  
A65-24683

EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION  
A65-27151

PB SE DIODE LASER FABRICATION, PROPERTIES AND EMISSION SPECTRUM WITH PEAK AT 8.5 MICRONS  
A65-27602

REFLECTION COEFFICIENT OF CAVITY TUBING AS EXPLANATION FOR POWER LEVEL OF HELIUM-NEON IR FABRY-PEROT INTERFEROMETER  
A65-30342

REVIEW OF SEMICONDUCTOR LASER DEVELOPMENTS NOTING MAGNETIC EFFECTS, MATERIALS FOR IR COHERENT RADIATION, OPTICAL LASER, HOLOGRAPHY, ETC  
A65-30594

ELECTRON DENSITY AND COLLISION FREQUENCY

# SUBJECT INDEX

# INTERFEROMETER

MEASUREMENTS IN TRANSIENT OSCILLATION OF IR AND VISIBLE HELIUM-NEON LASERS TO DETERMINE RELATIONSHIP BETWEEN OSCILLATIONS AND PLASMA PARAMETERS A65-34806

VISUAL PERCEPTION OF INTENSE COHERENT IR RADIATION FROM GAS LASER A65-34904

GAS MASER PUMP ANALOGOUS TO OPERATION OF HEAT ENGINE FOR EXCITING MASER ACTION IN FAR IR, DETAILING INTERACTION BETWEEN PURE ROTATIONAL STATES OF H CL AND HF A65-35312

THERMONUCLEAR FUSION CONTROL FOR ELECTRIC POWER CONVERSION - THETA PINCH, ION CYCLOTRON, AND INFRARED MASER DIAGNOSTICS N65-24859

QUANTUM-ELECTRONIC CROSS-MODULATION EFFECT NOTED WHILE MONITORING IR LASER INTERFEROMETRIC FRINGES A66-11449

C W IR LASER OSCILLATION IN H BR AND HI GAS DISCHARGE A66-16756

CARBON AND ETHYLENE TETRACHLORIDE ULTRASONIC MODULATORS APPLIED TO IR LASER HETERODYNE EXPERIMENTS ON IN AS PHOTODIODE A66-23353

INFRARED MASER INTERFEROMETRY FOR TIME AND SPACE RESOLUTION OF ELECTRON DENSITY IN HIGH TEMPERATURE PLASMAS ARL-65-135 N66-20024

**INFRARED RADIATION**

FAR IR GAS MASER OSCILLATOR DISCUSSING ENERGY LEVELS, PUMPING MOLECULAR RADIATION AND DETECTION A65-18849

CARBON MONOXIDE AND DIOXIDE VIBRATIONALLY INDUCED IR EMISSION WITH POSSIBLE APPLICATIONS TO CONTINUOUS LASER EMISSION A65-22463

MINORITY CARRIER LIFETIME IN SILICON MEASURED BY CONTACTLESS METHOD, USING LASER INDUCED MODULATION OF IR TRANSMISSION IN SILICON / LIRIS/ EFFECT A66-14563

HE- NE LASER IR RADIATION EMISSION ATTENUATED BY ATMOSPHERIC METHANE A66-23090

OPTICAL DISCRIMINATOR SYSTEM TO IDENTIFY INFRARED REFLECTING SURFACES FOR USE IN MASER RESEARCH HDL-TM-65-41 N66-17361

VISUAL PERCEPTION OF INFRARED LASER EMISSION NASA-TT-F-9888 N66-22300

**INFRARED SPECTRUM**

CRYSTALLINE CALCITE USED AS DICHROIC POLARIZER IN IR REGIONS, LASER RADIATION, ZEEMAN EFFECT AND NOISE PROPERTIES MEASUREMENTS, ETC A65-33419

INFRARED SPECTRUM, OPTICAL PROPERTIES, AND FABRICATION OF EIGHT-METER GAS LASER NEL-1242 N65-14446

PULSED GAS LASER FOR FAR INFRARED REGION OF SPECTRUM N65-20170

GAS IONIZATION PHENOMENON AT OPTICAL AND INFRARED FREQUENCIES - RUBY LASER INDUCED IONIZATION, FOCUSED SPOT DIAMETER, BREAKDOWN EMISSION, AND IONIZATION TIMES AND NONATTENUATION RADC-TR-64-568 N65-22250

**INJECTION**

COMMUNIST CHINA RESEARCH ON LIQUID, SOLID, GAS, PLASTIC, GLASS, AND INJECTION LASERS - APPLICATIONS IN MEDICINE, INDUSTRY, AND DEFENSE JPRS-33257 N66-14355

**INJURY**

LASER IRRADIANCE LEVELS FOR RETINAL LESIONS A66-80011

CHORIORETINAL LESIONS PRODUCED BY LASER ON MONKEY AND RABBIT A66-80950

**INSTRUMENTATION**

PROPERTIES OF LASERS AND APPLICATION TO SCIENTIFIC INSTRUMENTATION, COMMUNICATIONS, BIOLOGY, PRECISION MEASUREMENTS, METAL WORKING, AND MISCELLANEOUS AREAS AFCL-64-914 N65-16002

INSTRUMENTATION SYSTEM FOR MEASUREMENT OF PULSED LASER OUTPUT - CALCRIMETER AND INTEGRATOR WL-TR-64-127 N65-34706

**INTEGRAL EQUATION**

EIGENVALUES OF INTEGRAL EQUATIONS IN LASER RESONANT CAVITIES A66-21343

**INTERFERENCE**

RUBY LASER TEMPERATURE MEASUREMENT AND FILTERING BY DETERMINING SPECTRAL POSITION OF POLARIZATION INTERFERENCE BANDS A65-14184

INTERFERENCE FRINGE VISIBILITY UP TO 120 M OPTICAL PATH DIFFERENCE, USING HELIUM-NEON LASER SOURCE A65-16766

RELATION BETWEEN OPTICAL COHERENCE AND PHOTON STATISTICS, USING CLASSICAL AND QUANTUM THEORY, INTERFERENCE EXPERIMENTS AND PHOTODETECTION A65-24002

PICA OPTICAL INTERFERENCE FILTERS FOR SELECTED LASER FREQUENCIES AD-466027 N65-28608

INTERFERENCE EFFECTS AT THIN TRANSPARENT CYLINDRICAL GLASS FIBERS EXPOSED TO COHERENT LIGHT FROM HE- NE LASER A66-10368

FRAUNHOFER PATTERN OF LASER LIGHT TRANSMITTED THROUGH OPTICAL FIBER, NOTING SPATIAL FREQUENCY OF INTERFERENCE FRINGES BETWEEN LIGHT WAVES A66-14972

INTERFERENCE PHENOMENON OF SERRATED SYSTEM OF RINGS SURROUNDING CENTRAL BEAM OF GAS LASER ANALYZED, USING HELIUM NEON TUBE PLACED BETWEEN TWO EXTERIOR MIRRORS A66-17064

**INTERFEROMETER**

FREQUENCY RESPONSE AND CROSS COUPLING OF RED AND IR GAS LASER INTERFEROMETER FOR MEASURING PLASMA ELECTRON DENSITY A65-15819

GEOMETRICAL PROPERTIES COMMON TO ALL MODES OF OSCILLATION IN RADIATION FIELD OF LASER INTERFEROMETERS A65-18795

TWO POLARIZATION EIGENSTATES OCCURRING REPETITIVELY IN MULTIPLE PASS INTERFEROMETER CONTAINING ANISOTROPIC ELEMENTS, WITH PLANAR LASER EXAMPLE A65-21662

INTERFEROMETER USING SMALL DIFFRACTION GRATING AND GAS LASER LIGHT SOURCE IN SCHLIEREN SYSTEM FOR FLUID MECHANICS RESEARCH A65-25332

RUBY LASER ROD POSITION ALONG INTERFEROMETER AXIS, DETERMINING PRESENCE OF ADJACENT INTERFEROMETER MODES A65-25874

OBSERVATIONS OF RADIO SOURCES AT 9.4 GC WITH 2.2 FOOT FAN BEAM OF 16-ELEMENT INTERFEROMETER AND MASER AMPLIFIER A65-28335

TRANSVERSE MODES OF LASER ANALYZED WITH SCANNING INTERFEROMETER BY MATCHING RESPECTIVE MODES OF TWO DEVICES A65-29531

TIME RESPONSE OF HF LASER INTERFEROMETER USED IN PLASMA RESONANCE DETECTION A65-29791

SPIRAL FRINGES IN INTERFERENCE PATTERN OF INTERFEROMETER WITH LASER ILLUMINATION AS INDICATION OF DISCONTINUITY IN WAVE FRONT OR GENERATING SURFACE A65-33430

LASER INTERFEROMETER AND APPLICATION TO PLASMA PHYSICS AR0D-4832-2 N65-17210

- LASER INTERFEROMETER TO MEASURE TIME AND SPATIAL VARIATION IN REPETITIVELY PULSED PLASMA A66-10243 A66-21333
- AERODYNAMIC AND HEAT TRANSFER MEASUREMENTS USING INTERFEROMETER WITH CONTINUOUS WAVE LASER AS SOURCE A66-10849
- HE- NE LASER INCORPORATED INTO ARM OF INTERFEROMETER USED TO MEASURE FRINGE SHIFT IN SMALL TRANSIENT PLASMA A66-13743
- MEASUREMENT OF ELECTRON DENSITY OF GAS DISCHARGE PLASMA BY LASER INTERFEROMETER A66-16379
- ADVANTAGES OF GAS LASERS AS LIGHT SOURCES IN AERODYNAMIC RESEARCH INTERFEROMETERS A66-16944
- EFFECT OF HIGH VELOCITY TRANSLATION ON PHOTON CORRELATIONS IN LASER INTERFEROMETERS UCRL-14345 N66-10969
- PREIONIZATION AND SHOCK WAVE IONIZATION, ALFVEN WAVES, LASERS, AND INTERFEROMETER DEVELOPMENT NP-15355 N66-13913
- INTERFEROMETER SYSTEM**
- THREE-MIRROR CORNER-CUBE INTERFEROMETER SYSTEM WITH ROTATION INSENSITIVITY TO PRODUCE HIGH CONTRAST LASER FRINGES A65-18217
- LASER BEAM AMPLIFICATION BY REFLECTION FROM SCANNING GAS LASER ACTIVE INTERFEROMETER A65-33047
- LASER OSCILLATIONS AND SELF Q-SWITCHING, DISCUSSING PULSED FLASH-LAMP EXCITATION EXPERIMENTS WITH TRIPLY ACTIVATED CONFOCAL BARIUM CROWN GLASS ETALON A66-13980
- TWO LENSES WITH FOCAL RATIOS OF F/4 AND F/2.65 USED TO COLLIMATE LIGHT FROM HELIUM-NEON LASER A66-14921
- LASER APPLICATION AND TECHNIQUES NOTING AMPLIFICATION, MODULATION, INTERFEROMETRY, SCATTERING, PLASMA DIAGNOSTICS, NONLINEAR OPTICS, ETC A66-23931
- INTERFEROMETRY**
- OPTICAL AND LASER THRESHOLD MEASUREMENTS ON 39 FLAME-FUSION RUBIES TO OBTAIN HIGHEST OPTICAL QUALITY LASER RODS A65-16402
- RUBY-LASER ROD HOMOGENEITY DETERMINATION BY INTERFEROMETERS A65-19569
- PLASMA INTERFEROMETRY TECHNIQUE WHERE REFLECTED-BACK OUTPUT OF GAS LASER IS MODULATED, USING PHASE VARIATIONS A65-19754
- INTERFEROMETER EXPERIMENT OF HELIUM-NEON LASER SHOWS ITS RADIATION OBEYS LAWS OF CLASSICAL OPTICS A65-19994
- LOW ANGLE SCATTERING AND INTERFEROGRAPHIC MEASUREMENTS USED IN EVALUATING RUBY LASER RODS A65-33416
- RUBY CRYSTAL OPTICAL PROPERTIES INVESTIGATED BY INTERFERENCE RINGS FROM REFLECTING HE- NE LASER BEAM FROM CRYSTAL FACE A66-11045
- QUANTUM-ELECTRONIC CROSS-MODULATION EFFECT NOTED WHILE MONITORING IR LASER INTERFEROMETRIC FRINGES A66-11449
- LASER APPLICATION PROBLEMS IN INTERFEROMETRY, RADAR AND HOLOGRAPHY INCLUDING MECHANICAL STABILITY, NOISE SUPPRESSION, DIRTY LASER BEAM RESTORATION, ETC A66-11454
- CONVENTIONAL FLOW VISUALIZATION USING LASER LIGHT SOURCE AIAA PAPER 66-127 A66-17104
- LASER APPLICATION IN PHOTOGRAPHY, NOTING INTERFEROMETRIC AND HOLOGRAPHIC TECHNIQUES
- TWO-BEAM INTERFEROMETRY BY WAVEFRONT RECONSTRUCTION FROM HOLOGRAM RECORDED WITH COHERENT BACKGROUND SUCCESSIVELY INTERFERE IN SAME LATENT IMAGE A66-23204
- RUBY CRYSTAL OPTICAL PROPERTIES INVESTIGATED BY INTERFERENCE RINGS FROM REFLECTING HE- NE LASER BEAM FROM CRYSTAL FACE A66-23292
- POLISH-MADE HE- NE RED GAS LASERS, DESCRIBING POWER OUTPUTS, GAS PRESSURE, HE/ NE RATIO, MIRROR TRANSMISSION COEFFICIENT AND INTERFEROMETRIC APPLICATION A66-23946
- TIME RESOLVED INTERFEROMETRY, CINEMATOGRAPHY, AND TRAVELING WAVE CAVITY STUDIES ON RUBY LASERS AFCRL-65-467 N66-16656
- RUBY LASER RADIATION INTENSITY DISTRIBUTIONS BY HIGH SPEED CINEMATOGRAPHY AND TIME RESOLVED INTERFEROMETRY FOR PUMPED RADIATION EFFECTS N66-16657
- INFRARED MASER INTERFEROMETRY FOR TIME AND SPACE RESOLUTION OF ELECTRON DENSITY IN HIGH TEMPERATURE PLASMAS ARL-65-135 N66-20C24
- INTERMODULATION**
- GAS LASER CROSS MODULATION EFFECT WHEN EXPOSED TO FLASH TUBE RADIATION A65-15324
- INTERSTELLAR COMMUNICATION**
- COMBUSTION INSTABILITY, BALL LIGHTNING, SOLAR ACTIVITY, NOCTILUCENT CLOUDS, INTERSTELLAR COMMUNICATIONS, NEODYMIUM LASER, AND HYDROFOILS N65-34075
- SEARCH VIA LASER RECEIVERS FOR INTERSTELLAR COMMUNICATIONS A66-16669
- INVERSION**
- MASER DEVELOPMENT FROM INVERSIONAL TRANSITIONS IN HEAVY AMMONIA BEAM FTD-MT-64-330 N65-36869
- IODATE**
- GAS LASER OUTPUT AND THRESHOLD IN POPULATION INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE AND FLUCRO IODO METHYLIDYNE A66-16771
- ION BOMBARDMENT**
- CONSTRUCTION PROBLEMS OF CONTINUOUS-DUTY DC EXCITED ION LASERS A66-13956
- ION CHARGE**
- ARC-TUBE CONSTRUCTED FOR COOLING ARGON ION LASER - DISCHARGE TUBE GE/EE/65-1 N66-14188
- ION EMISSION**
- ENERGY AND INTENSITY OF IONS EMITTED BY METAL TARGET AS FUNCTION OF CHARACTERISTICS OF LASER AND NATURE OF METAL A66-15109
- TIME RESOLUTION OF ELECTRON AND ION EMISSION PRODUCED BY Q-SWITCHED RUBY LASER PULSE FOCUSED ON METAL SURFACE A66-18358
- ELECTRON AND ION EMISSION FROM PULSED RUBY LASER ILLUMINATED METALLIC SURFACE INTO VACUUM, DETERMINING APPLICATION TO PULSED ION THRUSTOR AIAA PAPER 66-230 A66-21453
- ION PRODUCTION**
- ION AND FREE ELECTRON PRODUCTION RATE STUDY IN GAS UNDER LASER BEAM ACTION A65-19727
- IONIC PROPULSION**
- PRODUCTION OF ION VELOCITIES OVER 4 KM/SEC BY FOCUSED RUBY LASER MAKES PRACTICAL APPLICATION IN DIRECT THRUSTORS AND AS PLASMA SOURCE IN ACCELERATOR TYPE THRUSTORS A65-23626
- IONIZATION**
- TRIGGERING OF BREAKDOWN OF NOBLE GASES SUBJECTED TO RUBY LASER RADIATION BY MULTIPHOTON

- IONIZATION**  
 REPT.-1935-3 N65-22851
- MECHANISMS ASSOCIATED WITH ELECTRICAL BREAKDOWN AND IONIZATION IN GAS CAUSED BY HIGH INTENSITY RUBY OR NEODYMIUM LASER ILLUMINATION D-920272-4 N66-11453
- PREIONIZATION AND SHOCK WAVE IONIZATION, ALFVEN WAVES, LASERS, AND INTERFEROMETER DEVELOPMENT NP-15355 N66-13913
- RUBY LASERS USED IN STUDYING PHYSICAL PROCESSES LEADING TO IONIZATION OF GASES BY INTENSE OPTICAL RADIATION UACRL-E920272-6 N66-20600
- IONIZATION CROSS SECTION**  
 HYDROGEN MOLECULE MULTIPHOTON IONIZATION, DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY RUBY LASER EMISSION A66-16517
- HYDROGEN MOLECULE MULTIPHOTON IONIZATION, DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY RUBY LASER EMISSION A66-20898
- MULTIPHOTON IONIZATION OF XENON ATOM IN POWERFUL ELECTRIC FIELD BY RUBY LASER RADIATION A66-21966
- IONIZATION FREQUENCY**  
 GAS IONIZATION PHENOMENON AT OPTICAL AND INFRARED FREQUENCIES - RUBY LASER INDUCED IONIZATION, FOCUSED SPOT DIAMETER, BREAKDOWN EMISSION, AND IONIZATION TIMES AND NONATTENUATION RADC-TR-64-568 N65-22250
- IONIZATION POTENTIAL**  
 IONIZATION UNDER LASER ACTION EXTENDED TO METALS AND DIELECTRICS, NOTING INFLUENCE ON THRESHOLDS A66-17065
- IONIZATION PHENOMENA IN ARGON DUE TO LASER RADIATION BY MEASURING ELECTRON DENSITY AND ENERGY AS TIME FUNCTION AFTER LASER PULSE INITIATION AT DIFFERENT GAS PRESSURES AND PREIONIZED CONDITIONS AIAA PAPER 66-176 A66-21690
- IONIZED GAS**  
 VISIBLE AND UV LASER OSCILLATION AT 118 WAVELENGTHS IN IONIZED NEON, ARGON, KRYPTON, XENON, OXYGEN AND OTHER GASES A65-22622
- GAS IONIZATION PHENOMENON AT OPTICAL AND INFRARED FREQUENCIES - RUBY LASER INDUCED IONIZATION, FOCUSED SPOT DIAMETER, BREAKDOWN EMISSION, AND IONIZATION TIMES AND NONATTENUATION RADC-TR-64-568 N65-22250
- TRAVELING FIELDS IN INTERACTION OF IONIZED GASES WITH ELECTROMAGNETIC FIELD CURRENTS CHECKING LORENTZ FORCE AND MAGNETIC INDUCTION A66-12980
- ISOTOPE SHIFT, LINEWIDTH AND PRECISE WAVELENGTH OF LASER EMISSION IN IONIZED HG A66-18035
- IONIZING RADIATION**  
 LABORATORY RESEARCH ON LASER EXCITATION IN SOLIDS, IONIZING RADIATION TRANSMISSION AND PLASMA JETS RELATED TO ASTROPHYSICS A65-14678
- OPTICAL ABSORPTION AND ELECTRON PARAMAGNETIC RESONANCE TECHNIQUES USED TO STUDY IONIZING RADIATION EFFECT ON RUBY LASERS NASA-TN-D-3379 N66-21037
- IRON**  
 LINE WIDTH AND INVERSION RATIOS OF IRON-DOPED RUTILE FOR OPTICAL MASER APPLICATIONS NASA-TM-X-54754 N65-29390
- IRRADIATION**  
 LASER IRRADIATION ON SECOND OPTICAL HARMONICS FTD-TT-65-25/1 N65-29889
- ISOTOPE**  
 ISOTOPE SHIFT, LINEWIDTH AND PRECISE WAVELENGTH OF LASER EMISSION IN IONIZED HG A66-18035
- ISOTOPE SHIFT**  
 ISOTOPE SHIFT MEASUREMENT FOR 6328 ANGSTROMS HELIUM-NEON LASER TRANSITION A66-21070
- J**
- JUNCTION**  
 ZINC DIFFUSION IN GALLIUM ARSENIDE-PHOSPHIDE LASERS AND EFFECTS ON SEMICONDUCTOR JUNCTIONS AFRCL-66-18 N66-22611
- JUNCTION DIODE**  
 LASER ACTION IN ALLOYED GALLIUM ARSENIDE JUNCTION DIODE SUBMERGED IN LIQUID NITROGEN A65-29198
- RADIATIVE TRANSITION PROCESS IN EMISSION SPECTRUM OF GALLIUM ARSENIDE P-N JUNCTION LASER DIODES A65-34666
- METHODS OF JUNCTION FORMATION TO OBTAIN ROOM TEMPERATURE GALLIUM ARSENIDE LASER DIODES CPR-3 N65-34184
- RISE OF JUNCTION TEMPERATURE DURING CONTINUOUS OPERATION OF GA AS INJECTION LASER A66-14771
- PARAMETER DEPENDENCE OF INTERMEDIATE FREQUENCY VOLTAGE INDICATED DURING ESTABLISHMENT OF OPTIMUM CONDITIONS FOR OPTICAL RECEIVERS AND MERIT OF SUBCARRIER MIXING A66-23960
- DEVELOPMENT OF SEMICONDUCTOR LIGHT SOURCES WITH RUBY LASERS AND ZINC-DOPED GA AS JUNCTION DIODES REPT.-6400-42-T N66-12450
- JUNCTION TRANSISTOR**  
 GENERAL PROGRESS OF SEMICONDUCTOR JUNCTION AND RUBY LASERS, ESPECIALLY IN EXPERIMENTAL FIELD A66-11370
- K**
- KA-BAND**  
 LOW NOISE KA-BAND TRAVELING WAVE MASER AMPLIFIER FOR WINDOW AT 8 MM WHERE ATMOSPHERIC ATTENUATION IS LOW A65-16565
- KERNEL FUNCTION**  
 INTEGRAL EQUATIONS GOVERNING MODE SPECTRA OF LASER, INVESTIGATING EXISTENCE OF EIGENVALUES FOR H-ORDER CONTINUOUS KERNELS A66-15806
- KERR CELL**  
 LASER OUTPUT SPIKING ELIMINATION USING KERR CELL CONTROLLED BY FEEDBACK CIRCUIT A65-24954
- OUTPUT AND DIVERGENCE MEASUREMENTS FOR Q-SWITCHED KERR CELL LASER REPT.-1579-18 N65-16819
- OPTICALLY BIASED PULSED TRANSMISSION MODE OPERATION OF Q-SWITCHED LASER, IN CONNECTION WITH KERR CELLS INHIBITING LASING ACTION A66-19937
- KERR EFFECT**  
 LIGHT DIFFRACTION BY GRATING DUE TO FARADAY AND KERR EFFECT IN ELECTROMAGNETIC FIELD OF LASER BEAM A65-26582
- HELIUM-NEON GAS LASER AS LIGHT SOURCE FOR MAGNETO-OPTICAL APPARATUS - KERR MAGNETO-OPTICAL EFFECT OF FERROMAGNETIC IRON-NICKEL THIN FILM N65-26766
- KINETIC EQUATION**  
 KINETIC EQUATION TO DESCRIBE CONTINUOUS WAVE LASER RADIATION INSTABILITY A65-19739
- KINETIC EQUATION OF LASER OPTIMUM EMISSION, DETERMINING PUMPING EFFICIENCY, VALUE OF LOSSES IN SPECIAL MODES, ETC A66-11058
- SECOND HARMONIC GENERATION BY LASER BEAMS OF FINITE SPECTRAL WIDTH, USING QUANTUM TRANSITIONS AND KINETIC EQUATIONS, NOTING SHAPE OF PUMPING

LINE AT FUNDAMENTAL FREQUENCY A66-22026

**KINETICS**  
 RUBY LASER TEMPERATURE-JUMP RELAXATION KINETIC STUDIES OF RAPID REACTIONS  
 UUCD-2-64 N66-23078

**KLYSTROM**  
 IMPROVED MASER PERFORMANCE THROUGH GAIN STABILITY IF PUMP FLUCTUATIONS ARE KEPT TO MINIMUM BY ELIMINATION OF TWO OF FOUR VARIABLES A65-21324

**KRYPTON**  
 HIGH POWER MERCURY LASER OPERATIONS IN KRYPTON AND ARGON AS FUNCTION OF MAGNETIC FIELD  
 QPR-2 N65-22323

**L**

**L-BAND**  
 EXPERIMENTAL L-BAND TRAVELING WAVE MASER DEVELOPED WITH EXCEPTIONALLY WIDE TUNING RANGE A66-15958

**LABORATORY APPARATUS**  
 LABORATORY RESEARCH ON LASER EXCITATION IN SOLIDS, IONIZING RADIATION TRANSMISSION AND PLASMA JETS RELATED TO ASTROPHYSICS A65-14678

**LABYRINTH**  
 EFFECT OF LASER IRRADIATION ON INNER EAR IN PIGEONS A66-80961

**LAMB WAVE**  
 STABILITY AND SOLUTION OF EQUATIONS OF MOTION FOR TRAVELING WAVE INTERACTIONS IN LASERS A65-19726

**LAMINAR BOUNDARY LAYER**  
 PROPAGATION OF ATMOSPHERICS, RADIATIVE RECOMBINATION IN LASERS, RADIATION BELT SURROUNDING EARTH, EQUATION FOR LAMINAR BOUNDARY LAYER PROBLEMS, AND RARE EARTH SILICIDES N66-12644

**LAMP**  
 PULSED XENON FLASHLAMP AND CONTINUOUS INCANDESCENT TUNGSTEN LAMP TRADEOFFS AS NEODYMIUM-YTTRIUM ALUMINUM GARNET CRYSTAL LASER PUMPS  
 REPT.-3 N65-30242

SEMICONDUCTOR INJECTION LASERS AND LAMPS  
 RAE-TR-65095 N65-36334

**LANGMUIR PROBE**  
 ENERGY LEVEL RELATIVE POPULATION DENSITIES OF NEON PLASMA USING HELIUM-NEON LASER - LANGMUIR PROBE ADDITIONS FOR MEASUREMENT OF PLASMA ELECTRON TEMPERATURE AND VELOCITY DISTRIBUTIONS  
 ARL-65-246 N66-22488

**LANTHANUM COMPOUND**  
 GROWTH OF HIGH OPTICAL QUALITY LANTHANUM-ALUMINUM OXIDE SINGLE CRYSTAL BY CZOCHRALSKI METHOD - DEFENDER PROJECT  
 SRCR-65-4 N65-34084

**LANTHANUM FLUORIDE**  
 LASER RESEARCH DEALING WITH EFFECT OF PUMPING ON RUBY QUALITY, LANTHANUM FLUORIDE EXAMINATION, LARGE RUBY LASER RODS, DC OPERATION OF MERCURY TUBE, HOLOGRAMS, AND LASER PHYSICS  
 NRL-MR-1604 N65-28920

**LANTHANUM OXIDE**  
 GROWTH OF HIGH OPTICAL QUALITY LANTHANUM-ALUMINUM OXIDE SINGLE CRYSTAL BY CZOCHRALSKI METHOD - DEFENDER PROJECT  
 SRCR-65-4 N65-34084

**LAPLACE TRANSFORM**  
 FABRY- PEROT MULTILAYER LASER AMPLIFIER SOLUTIONS FROM TRANSIENT THEORY POINT OF VIEW, USING LAPLACE TRANSFORM A65-29926

**LARGOS SATELLITE**  
 HIGH ENERGY LASER SYSTEM FOR LARGOS GEODETIC SATELLITE OPTICAL TRACKING

B-3011 N66-14591

**LASER MODE**  
 SPECTRAL LINE SHAPE FOR FABRY- PEROT MASER USING VARIOUS OSCILLATION MODES A65-14113

HIGH SYMMETRY OSCILLATIONS IN CONTINUOUS WATER COOLED SOLID STATE LASERS, SHOWING RELATION TO EXCITATION CONDITIONS A65-14185

TRAVELING-WAVE TUBE WITH PHOTOELECTRIC CATHODE USED AS DEMOCULATOR FOR LASER COMMUNICATION A65-14345

MODE SUPPRESSION AND MODE STABILIZATION OF HELIUM-NEON LASER, USING TUNGSTEN WIRES AS MODE DISCRIMINATOR A65-15325

ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS LASER WITH PLANE PARALLEL MIRRORS A65-15458

INTEGRAL EQUATIONS GOVERNING MODE SPECTRA OF LASER, INVESTIGATING EXISTENCE OF EIGENVALUES FOR HOLDER CONTINUOUS KERNELS A65-15806

BEHAVIOR OF COUPLING-TYPE INTERNAL LASER MODULATORS WITH BANDWIDTH COMPARABLE TO MODE SPACING A65-16404

FREQUENCY SPECTRA MEASUREMENT OF GASEOUS LASER BY PHOTOMIXING TECHNIQUES AND NOISE DISTRIBUTION A65-16405

AXIALLY UNIFORM ENERGY DENSITY IN LASER CAVITY OBTAINED, USING BIREFRINGENT SAPPHIRE QUARTER WAVE PLATES, RUBY ROD AND TWO MIRRORS A65-16407

MODE IMPURITY OBSERVED IN DIFFRACTION MEASUREMENTS EMPLOYING GAS LASER APPARENTLY RESONATING IN TEM-00 MODE A65-16571

LOCKING OF MODES IN HE- NE LASER AT 6328 ANGSTROMS, USING EXTERNAL DOPPLER CELL A65-16668

IN SB LONGITUDINAL INJECTION-PLASMA LASER, NOTING PLASMA PINCH AND MODE STRUCTURE A65-17210

MULTIMODE LASER OSCILLATION RESULTING FROM MODULATION OF DIELECTRIC CONSTANT AND OF LOSS OR GAIN OF LASER MEDIUM A65-17652

RUBY LASER POWER DEPENDENCE ON FREQUENCY SPLITTING OF TWO COMPONENTS OF R1 DOUBLET AT 77 DEGREES K A65-17654

FABRY- PEROT GALLIUM ARSENIDE LASER HIGHER ORDER AXIAL MODE TEMPERATURE DEPENDENCE A65-17655

CURRENT DISTRIBUTION CONTROL IN GALLIUM ARSENIDE INJECTION LASER SHOWING EFFECTS ON OSCILLATION MODE AND THRESHOLD A65-17665

OPTICAL CAVITY IN WHICH MODES ARE DETERMINED AS STATIONARY STATES OF DIFFRACTION-LIMITED OBJECT/ IMAGE TRANSFORMATION OF CLASSICAL OPTICS A65-18013

HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE EXCITATION AND GENERATION KINETICS IN RUBY LASER WITH CONCENTRIC CAVITY A65-18460

CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL RUBY CRYSTALS DUE TO TC HEATING BY EXCITING LIGHT A65-18461

OPTIMUM LASER EMISSION MODES RESULTING FROM HOLLOW CATHODE TUBE DISCHARGE DUE TO INELASTIC HELIUM NEON ATOM COLLISIONS A65-18556

LASER OPERATION MODES ARISING FROM METASTABLE NEON ATOM ANNIHILATION BY HYDROGEN AND OXYGEN MOLECULES A65-18557

GEOMETRICAL PROPERTIES COMMON TO ALL MODES OF

# SUBJECT INDEX

# LASER MODE CONT

- OSCILLATION IN RADIATION FIELD OF LASER INTERFEROMETERS A65-18795
- AMPLITUDE NOISE MEASUREMENT FOR CAVITY TYPE GASEOUS OPTICAL MASER OSCILLATOR ABOVE AND BELOW THRESHOLD A65-19544
- REQUIREMENTS FOR GENERATING TRULY CIRCULAR MODE OF OSCILLATION IN GAS LASER SYSTEM A65-19602
- EXPERIMENTAL OSCILLATION OF TWO LASERS AT SAME FREQUENCY WITH PHASE DIFFERENCE OF LESS THAN ONE THIRD DEGREE A65-19603
- PLANE STATIONARY MODE OF TM LASER AMPLIFIER WITH FEEDBACK A65-19683
- KINETIC EQUATION TO DESCRIBE CONTINUOUS WAVE LASER RADIATION INSTABILITY A65-19739
- MINIMUM VALUE OF TIME DEPENDENT LASER RADIATION LOSSES AT WHICH GIANT OSCILLATIONS OCCUR A65-19740
- INTERFEROMETER EXPERIMENT OF HELIUM-NEON LASER SHOWS ITS RADIATION OBEYS LAWS OF CLASSICAL OPTICS A65-19994
- OSCILLATORY BEHAVIOR OF NEODYMIUM DOPED CALCIUM TUNGSTATE SOLID STATE LASERS WITH CW EMISSION BASED ON RATE EQUATIONS A65-19998
- CHEMICAL LASER WITH INPUT ENERGY DERIVED SOLELY FROM CHEMICAL REACTION PRODUCED RADIATION, NOTING PROCESS OF COHERENT LIGHT PRODUCTION A65-20001
- LASER OSCILLATION FREQUENCY AND AMPLITUDE FLUCTUATIONS MEASURED BY DELAY LINE AND SQUARE LAW DETECTOR A65-20510
- SMALL STABLE HELIUM-NEON LASER CONSTRUCTION AND MODE PATTERNS A65-21256
- RESONANT MODES OF UNSTABLE OPTICAL RESONATORS AND LOSSES A65-21299
- SINGLE MODE OUTSIDE DIFFERENTIAL QUANTUM EFFICIENCIES OF CIRCULAR AND RECTANGULAR LASER DIODES COMPARED A65-21321
- SELF-INDUCED OSCILLATIONS IN OUTPUT OF FABRY-PEROT GALLIUM ARSENIDE INJECTION LASER A65-21624
- EFFECT OF PARTIALLY SHIELDING RUBY LASER ROD FROM PUMP LIGHT UPON LONGITUDINAL MODE SPECTRA OF LASER A65-21657
- TWO POLARIZATION EIGENSTATES OCCURRING REPETITIVELY IN MULTIPLE PASS INTERFEROMETER CONTAINING ANISOTROPIC ELEMENTS, WITH PLANAR LASER EXAMPLE A65-21662
- LASER OSCILLATION WHEREIN LASER MODES OSCILLATE WITH APPROXIMATELY FM PHASES THEREBY COMPRISING SIDEBANDS OF FM LIGHT SIGNAL A65-21876
- VISIBLE AND UV LASER OSCILLATION AT 118 WAVELENGTHS IN IONIZED NEON, ARGON, KRYPTON, XENON, OXYGEN AND OTHER GASES A65-22622
- ORBITAL SPHERICAL CAVITY MODE APPROACH TO MODE STRUCTURE OF LASER RESONATOR, USING VECTOR WAVE EQUATION A65-22932
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM FLUORIDE DOPED WITH SAMARIUM A65-24085
- MODE LOCKING IN HELIUM-NEON LASER BY MEANS OF SYNCHRONOUS INTRACAVITY ACOUSTIC MODULATION IN COUPLED MULTIMODE CONFOCAL INTERFEROMETERS A65-24276
- NATURAL MODES OF PLANE AND CYLINDRICAL DIELECTRIC RESONATORS IN OPTICAL BAND A65-24810
- LASER OSCILLATION AND ENERGY LOSSES IN MEDIUM CONTAINING ACTIVE MOLECULES A65-24811
- STABILITY PARAMETER, SPOT SIZE AND WAVE FRONT CURVATURE OF GAUSSIAN BEAM IN RING RESONATOR CONTAINING UP TO FOUR UNEQUALLY SPACED SPHERICAL MIRRORS A65-24910
- DIFFRACTION LOSSES, PHASE SHIFTS AND FIELD DISTRIBUTION FUNCTIONS FOR TWO LOWEST-ORDER MODES ON INTERFEROMETER-TYPE MASER RESONATORS WITH CIRCULAR MIRRORS A65-24911
- SPECTRAL LINE SHAPE FOR FABRY-PEROT MASER USING VARIOUS OSCILLATION MODES A65-24933
- RUBY LASER ROD POSITION ALONG INTERFEROMETER AXIS, DETERMINING PRESENCE OF ADJACENT INTERFEROMETER MODES A65-25874
- INSTABILITY IN LASER AMPLIFIER MEDIUM OCCURRING AT HIGH PUMPING LEVELS, GIVING TRANSMISSION LINE EQUIVALENT CIRCUIT FOR PLANE WAVE PROPAGATION A65-25888
- LASER MODEL POSSESSING TWO MODES OF DIFFERENT VIBRATIONAL FREQUENCY A65-26026
- SINGLE-MODE SELECTION AND MODE VOLUME ENHANCEMENT IN HE-NE GAS LASER WITH INTERNAL LENS A65-26820
- LASER BEAM MULTIMODE EFFECTS AS HINDRANCE TO INTERPRETATION OF QUANTITATIVE MEASUREMENTS OF RAMAN GAIN A65-26958
- OPTIMUM LASER EMISSION MODES RESULTING FROM HOLLOW CATHODE TUBE DISCHARGE DUE TO INELASTIC HELIUM NEON ATOM COLLISIONS A65-27149
- LASER OPERATION MODES ARISING FROM METASTABLE NEON ATOM ANNIHILATION BY HYDROGEN AND OXYGEN MOLECULES A65-27150
- LASER MODE DEFORMATION FROM NONUNIFORMITIES IN GAIN SATURATION A65-27328
- LASER OPERATION AS PULSED REGENERATIVE OSCILLATOR ARISING FROM MODE COUPLING DUE TO TIME-VARYING LOSS IN CAVITY OR NONLINEAR CHARACTERISTICS OF INVERTED POPULATION A65-27603
- FREQUENCY SEPARATION BETWEEN TRANSVERSE MODES OF RUBY LASER MEASURED BY FABRY-PEROT INTERFEROMETER AND VERIFIED BY TRANSVERSE MODE SELECTION A65-27610
- TIME DEPENDENCE OF LASER OPERATION MODES USING LASER MODEL WITH TWO OSCILLATION TYPES A65-27772
- HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE EXCITATION AND GENERATION KINETICS IN RUBY LASER WITH CONCENTRIC CAVITY A65-28089
- CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL RUBY CRYSTALS DUE TO HEATING BY EXCITING LIGHT A65-28090
- SYNCHRONIZED MODE OF EXCITATION FOR DIFFRACTION-COUPLED LASER A65-28538
- ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS LASER WITH PLANE PARALLEL MIRRORS A65-28554
- SUPERMODE LASER AS SINGLE-FREQUENCY GENERATION SYSTEM CONSISTING OF FM LASER WITH SYNCHRONOUS PHASE MODULATOR AT OUTPUT A65-29267
- FREQUENCY STABILIZATION OF DOUBLE MODE HELIUM-NEON LASER VIA PHASE LOCK CIRCUIT A65-29411
- OPTICAL SIMULATION OF MICROWAVE ANTENNAS WITHOUT DIRECT FREQUENCY SCALING, OBTAINING AMPLITUDE DISTRIBUTION OF LASER RADIATION FIELDS A65-29418
- SPECTROMETER FOR LASER OSCILLATION FREQUENCIES AND

- MODES ANALYSIS A65-29430
- TRANSVERSE MODES OF LASER ANALYZED WITH SCANNING INTERFEROMETER BY MATCHING RESPECTIVE MODES OF TWO DEVICES A65-29531
- STABILITY OF CORRECTED COUPLED-MODE LASER EQUATION DERIVED FROM MODEL FOR RUBY LASER SPIKING RESULTING FROM MODE INTERFERENCE A65-29805
- NATURAL SELECTION OF MODES USING PASSIVE Q-SWITCH IN GIANT PULSE RUBY LASER WHICH NARROWS OUTPUT SPECTRUM A65-29850
- SINGLE AXIAL MODE OPERATION OF RUBY LASER AT ROOM TEMPERATURE, USING SATURABLE FILTER Q-SWITCH AND RESONANT REFLECTOR A65-29852
- EQUATIONS DESCRIBING HEAT FREQUENCY VARIATION AND MODE COMPETITION IN GASEOUS LASER OPERATED IN MAGNETIC FIELD PARALLEL TO LASER AXIS A65-30303
- LASER ACTION AT LIQUID HELIUM TEMPERATURE IN CRYSTALS OF LEAD SAMARIUM, LEAD SELENIDE AND LEAD TELLURIDE EXCITED BY FAST ELECTRON BEAM A65-30346
- RELAXATION OSCILLATIONS IN FOUR-LEVEL SOLID STATE LASER STUDIED VIA DIFFERENTIAL EQUATIONS, CALCULATING SHAPE AND ENVELOPE OF OSCILLATION A65-30574
- STATISTICS OF MULTIMODE LASER SIGNALS DERIVED AND COMPARED WITH THOSE OF INCOHERENT RADIATION A65-31034
- SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-31306
- H F MODULATION OF RADIATION SPIKES DUE TO BEATS BETWEEN OSCILLATION MODES IN OPTICAL RUBY LASER A65-31701
- LASER PULSE-SHAPING AND MODE-LOCKING WITH TRAVELING AND STATIONARY ACOUSTIC WAVES IN ARGON LASER A65-31763
- LASER OPERATION PRINCIPLES AND OSCILLATING ELEMENT OF LASER RESONATOR A65-31880
- QUASI-FERMI LEVEL, FREQUENCY, THRESHOLD PUMPING VALUE AND PARTICULAR MODE IN RADIATIVE INTRABAND TRANSITION A65-31884
- HE-NE GAS LASER OSCILLATING IN TWO LINEARLY POLARIZED MODES, COMPARING THEORETICAL AND EXPERIMENTAL MODE INTENSITIES AND BEAT FREQUENCIES A65-32844
- LASER BEAM AMPLIFICATION BY REFLECTION FROM SCANNING GAS LASER ACTIVE INTERFEROMETER A65-33047
- EFFICIENT DIFFRACTION OF INCIDENT LASER BEAM AT BRAGG ANGLE INCIDENCE INTO FIRST-ORDER MODE, USING TRAVELING ULTRASONIC WAVES IN WATER A65-33057
- SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-33352
- RESONANT WAVES IN FABRY-PEROT INTERFEROMETER INVESTIGATED ON BASIS OF STANDING WAVE TYPE FORMULATION A65-33516
- RADIATIVE TRANSITION PROCESS IN EMISSION SPECTRUM OF GALLIUM ARSENIDE P-N JUNCTION LASER DIODES A65-34666
- INTENSITY FLUCTUATIONS MEASURED IN EMISSION FROM VARIOUS LASING AND NONLASING MODES OF CONTINUOUS WAVE GAS LASER A65-34687
- FAR FIELD PATTERNS OF OFF-AXIAL MODES IN CYLINDRICAL GLASS NEODYMIUM LASER RODS A65-34807
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM FLUORIDE DOPED WITH SAMARIUM A65-34906
- LASER DOPPLER FLOWMETER MEASUREMENT TECHNIQUE FOR LOCALIZED FLOW VELOCITIES IN GAS, NOTING RELIABILITY FOR HIGH FLOW VELOCITIES A65-35061
- MODE LOCKING EFFECTS IN INTERNALLY KDP MODULATED RUBY LASER A65-35063
- HIGH SPEED PHENOMENA HOLOGRAMS PRODUCED BY RADIATION FROM PULSED RUBY LASER OPERATED EITHER IN Q-SWITCHED OR CONVENTIONAL MODE A65-35067
- LASER MODE OPERATION IN PRESENCE OF RADIATION ABSORBING IMPURITY ANALYZED BY EXTENDED THOMSON TYPE SYSTEM A65-35930
- CIRCULAR DIELECTRIC RESONATOR UNDER CRITICAL OPERATING CONDITIONS IN ANALYSIS OF PERFORMANCE AND ENERGY LOSS A65-36011
- STEADY STATE OSCILLATIONS OF MOLECULAR BEAM LASER WITH INHOMOGENEOUS SINUSOIDAL FIELD IN RESONATOR A65-36561
- MODE DEGENERACY-DIPS ON OUTPUT OF HE-NE LASER FOR CERTAIN CRITICAL COMBINATION OF MIRROR CURVATURES AND SEPARATION A65-36703
- CONTROLLING FM AND SUPERMODE LASER OUTPUT FREQUENCIES BY THRESHOLD CONTROL AND INTERFEROMETRIC CONTROL A65-36842
- THEORETICAL STUDY OF RESONANT MODES OF LASER CAVITY WITH END MIRRORS AND PERIODIC REFLECTIVITY AFCL-64-1015 N65-17931
- IONIZATION BREAKDOWN MECHANISMS OF GASES AT OPTICAL INFRARED FREQUENCIES USING LASERS RADC-TDR-64-422 N65-18624
- GASEOUS AND SOLID LASER LINES SURVEY FOR LASER SPECTROSCOPY AND PLASMA DIAGNOSTICS NASA-CR-57334 N65-19752
- RADIATION SCATTERING FROM LASER BEAM BY FREE PLASMA ELECTRONS NSL-64-168-1 N65-20300
- SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION, CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION, FREQUENCY MODULATION LASERS, AND GALLIUM COMPOUND INGOTS FOR LASER APPLICATION AFCL-64-1007 N65-23135
- FREQUENCY MODULATION LASER WITH COMPOSITE AXIAL MODES N65-23138
- STATISTICAL CHARACTERISTICS OF AUTOMODULATION OF SOLID LASER RADIATION N65-27234
- SELF-LOCKED GAS LASER MODE DEPENDENCE ON CAVITY LENGTH AND POSITION OF LASER MEDIUM IN CAVITY A66-10347
- PHASE RELATIONS OF LONGITUDINAL MODES IN GAS LASER WITH ANNULAR RESONATOR A66-10726
- INDUCED EMISSION MODES OF TRAVELING WAVE LASER A66-10778
- GAS LASER INTERFEROMETERS FOR PLASMA LOW ELECTRON DENSITY MEASUREMENT A66-10856
- TWO- AND THREE-STEP LASER CASCADES DETECTED EXPERIMENTALLY IN HELIUM-NEON MIXTURES, ANALYZING TWO-STEP CASCADE STARTING WITH DENSITY MATRIX FORMULATION A66-11477
- LASER MODEL POSSESSING TWO MODES OF DIFFERENT VIBRATIONAL FREQUENCY A66-11728

- OPTICAL WHISPERING MODE OF POLISHED CYLINDERS AND IMPLICATION IN LASER TECHNOLOGY, NOTING TRAPPED FLUORESCENT LIGHT A66-12203
- MODE-CONTROLLED GIANT PULSE LASER USED TO PRODUCE TWO-BEAM HOLOGRAM IN SHORT EXPOSURE TIME OF 30 NSEC A66-12215
- SYNCHRONIZED MODE OF EXCITATION FOR DIFFRACTION-COUPLED LASER A66-12293
- LASER EXCITATION IN QUARTZ OF ELASTIC MODES OF THICK PLATE, SUGGESTING ENERGY COUPLING MECHANISMS A66-12423
- PRESSURE DEPENDENCE OF DOMINANT EMISSION MODES FROM Pb Se Diode Laser A66-13003
- MULTIREFLECTOR FABRY-PEROT LASER RESONATORS, DISCUSSING SUPPRESSION EFFECT AGAINST UNWANTED MODES A66-13325
- TIME CHARACTERISTICS IN GENERATION OF GIANT LASER PULSE STUDIED BY CIRCUIT WITH PRISMATIC SHUTTERS A66-13889
- MODE GUIDING AND GAIN IN JUNCTION LASER DUE TO DIELECTRIC SANDWICH CONFINING WAVE PROPAGATION A66-13952
- F M LASER OSCILLATION THEORY DISCUSSING EFFECT OF ARBITRARY ATOMIC LINE SHAPE, SATURATION, MODE PULLING, POWER OUTPUT, SIDEBAND AMPLITUDE, DISTORTION, ETC A66-13954
- MODES OF EMISSION-VS-TIME SPECTRUM, OPTICAL EMISSION SPECTRUM AND SUPERPOSITION SPECTRUM OF SHORT CONFOCAL RUBY LASER IN NEAR FIELD A66-14290
- SPATIAL DISTRIBUTION OF HOLLOW-CONE SHAPED EMISSION OF MODES WHICH ARE TOTALLY REFLECTED IN NEODYMIUM-GLASS LASERS A66-14291
- MODE SELECTIVE CHARACTERISTICS OF PLANE-PARALLEL DIELECTRIC PLATE AS REFLECTOR FOR RUBY LASER RESONATOR A66-14330
- MODE OF OPERATION OF VARIOUS RUBY LASERS WITH PLANE-PARALLEL MIRRORS AT ROOM TEMPERATURE A66-14500
- LASER DEFLECTION AND SCANNING BY MEANS OF MULTIMODE CAVITIES WITH DYNAMIC SPATIAL FILTERS A66-14829
- LASER LIGHT REDISTRIBUTION IN ILLUMINATING OPTICAL SIGNAL PROCESSING SYSTEMS NOTING APODIZATION, SPATIAL MODES AND ASPHERIC ELEMENTS A66-14830
- MICROWAVE BEATS IDENTIFIED BETWEEN MODES IN BROMINE-ARGON MIXTURE A66-14923
- PERIPHERAL MODES IN CHELATE LASER, NOTING LUMINESCENCE EMITTED BY AXIS OF CYLINDRICAL CELL AND LATERAL FACE A66-15171
- MODE COMPETITION AND COUPLING IN Q-SWITCHED RUBY LASER A66-16383
- C W LASER OSCILLATION BETWEEN 11.48 AND 11.55 MICRONS FROM NITROGEN-CARBON DISULFIDE SYSTEM A66-16384
- TIME DEPENDENCE OF LASER OPERATION MODES, USING LASER MODEL WITH TWO OSCILLATION TYPES A66-16626
- MULTIPLE INTERNAL-REFLECTION FOLDED-PATH RECTANGULAR LASER CONFIGURATION FOR OBTAINING LENGTH OF ACTIVE MEDIA BETWEEN FABRY-PEROT REFLECTORS A66-16652
- C W IR LASER OSCILLATION IN H BR AND HI GAS DISCHARGE A66-16756
- DERIVATION OF TWO EQUATIONS FOR ELECTROMAGNETIC FIELD AND POPULATION INVERSION IN SOLID STATE LASER A66-16773
- SELF-MODULATION OF LASER WITH TWO-MODE RESONATOR A66-16775
- OSCILLATION MODE CONTROL IN P-N JUNCTION LASERS FOR CURRENT DENSITY REDUCTION FOR STIMULATED EMISSION A66-17329
- INTENSITY DISTRIBUTION OF FRINGE SYSTEMS USED TO VERIFY PHASE INVERSION BETWEEN TWO LOBES OF LASER IN TEM-10 MODE A66-17453
- SOLID STATE LASER SYSTEM, DESCRIBING QUANTUM MECHANICAL TREATMENT OF SELF-SUSTAINED OSCILLATION FOR ONE MODE A66-17817
- GENERATION OF INDUCED LASER RADIATION IN PRESTATIONARY REGIME A66-17877
- QUASI-FERMI LEVEL, FREQUENCY, THRESHOLD PUMPING VALUE AND PARTICULAR MODE IN RADIATIVE INTRABAND TRANSITION A66-18361
- PHASE-LOCKING EFFECT AND PHASE SUM OF LF AND HF OSCILLATING MODES IN LASER A66-18413
- LASER EMISSION IN PURE CADMIUM SULFIDE CRYSTALS BOMBARDED BY ELECTRON BEAMS A66-18650
- H F MODULATION OF RADIATION SPIKES DUE TO BEATS BETWEEN OSCILLATION MODES IN OPTICAL RUBY LASER A66-19955
- TIME DEPENDENT EMISSION BEHAVIOR OF SINGLE AXIAL MODE OF DIFFRACTION LIMITED RUBY LASER AT ROOM TEMPERATURE A66-20420
- NEODYMIUM DOPED GLASS LASER FOUND TO OSCILLATE IN CONVENTIONAL RANDOM PULSATING MANNER UNDER MODE-LOCKED CONDITIONS A66-21251
- SINGLE FILAMENT JUNCTION LASER EMITTING COHERENT LIGHT OF SIMPLER MODES, SHOWING THAT LASER HAS TWO PORTIONS, EACH WITH SELECTIVE DIFFUSED REGION A66-21357
- INDUCED EMISSION MODES OF TRAVELING WAVE LASER A66-22290
- QUANTUM MECHANICAL NONLINEAR THEORY OF INTENSITY AND PHASE FLUCTUATIONS OF HOMOGENEOUSLY BROADENED LASER NOISE A66-22466
- PARASITIC INTERNAL OSCILLATIONS IN LASER CRYSTAL WITH DIELECTRIC ROD CAUSED BY TOTAL REFLECTION FROM GENERATRIX OF CYLINDRICAL SAMPLE A66-22739
- STANDING WAVES IN LASER RESONATORS VERIFIED BY PLACING THIN METALLIC FILMS BETWEEN EXTERNAL MIRRORS OF PULSED NEODYMIUM LASER A66-22893
- MODE SUPPRESSION TECHNIQUES FOR GAS LASER SINGLE AXIAL MODE OPERATION FOR LARGE MIRROR SEPARATIONS A66-23093
- EXCITATION OF AXIAL OSCILLATION MODES IN SEMICONDUCTOR LASERS ANALYZED, BASED ON RATE EQUATIONS FOR CHEMICAL POTENTIALS OF CARRIERS AND NUMBER OF PHOTONS A66-24455
- EQUATIONS OF MOTION GOVERNING INTERACTION OF OPTICAL MODES IN PRESENCE OF TIME-VARYING PARAMETERS A66-24559
- TWO-LEVEL ATOM INTERACTION WITH MULTIMODE GAS LASER CAVITY, OBTAINING STATIONARY STATE AND SOLVING UNIQUE EIGENVALUE IN SPECIAL CASES A66-24568
- DEPENDENCE OF BEAT FREQUENCY OF NEODYMIUM LASER AXIAL MODES ON DISTANCE BETWEEN MIRRORS AND NEODYMIUM ROD POSITION WITHIN RESONATOR A66-24881
- PROPERTIES OF FREQUENCY MODULATION AND SUPER MODE LASER



## LASER OUTPUT

## SUBJECT INDEX

- IER-1 N66-10766
- ARC-TUBE CONSTRUCTED FOR COOLING ARGON ION LASER - DISCHARGE TUBE GE/EE/65-1 N66-14188
- LASER RESEARCH ACTIVITIES IN CHINESE PEOPLES REPUBLIC - FORMATION OF MICROWAVE MASER BY LASER PUMPING, AND FORMATION TIME OF GAS LASER OSCILLATIONS JPRS-33323 N66-15048
- TIME DEPENDENCY OF COUPLED MODE LASER OSCILLATION UCRL-7497 N66-20355
- LASER OUTPUT**
- SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF PULSED RUBY LASER OUTPUT A65-14131
- RADIATION FLUCTUATIONS IN LASER PULSE REGIME, DISCUSSING ERRORS ARISING IN COMPARING BASIC WITH SECONDARY EMISSION A65-14617
- OPTICAL RADAR OBSERVATION OF UPPER ATMOSPHERIC CONSTITUENTS BY LASER BEAMS, EXAMINING NEW METHODS BY RESONANCE SCATTERING OF VARIOUS WAVELENGTHS A65-14683
- PARAMETRIC DEPENDENCE OF TIME PROFILE, PEAK POWER AND NUMBER OF GIANT PULSES OF ROTATING PRISM Q-SWITCHED LASERS A65-15103
- MICROWAVE ELECTRON CYCLOTRON RESONANCE PUMPING OF NEON-HELIUM LASER TO RAISE PLASMA ELECTRON TEMPERATURE FOR INCREASE OF OUTPUT A65-15320
- POWER DENSITY IN NOISE SIDEBANDS OF LASER CAUSED BY EMISSION NOISE IN ACTIVE MEDIUM A65-15321
- GAIN SATURATION, LIGHT POWER LEVEL, DISCHARGE CURRENT AND METHOD FOR SPECIFYING OUTPUT POWER CHARACTERISTICS OF LASER TUBE A65-15326
- FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS SYSTEMS, PRIMARILY LIGHT ABSORPTION AND ATMOSPHERIC SCATTERING A65-15349
- SINGLE PULSES OF ELECTRON EMISSION PRODUCED BY SPINNING-PRISM Q-SWITCHED RUBY LASER A65-15443
- LASER EMISSION USED FOR HEATING PLASMA WITH INITIAL DENSITY NEAR ZERO A65-15535
- NANOSECOND HEATING OF AQUEOUS SYSTEMS BY Q-SWITCHING ROTATING PRISM RUBY LASER A65-15788
- BUILDUP AND DECAY TRANSIENT EFFECTS IN GAS LASERS DUE TO LIGHT ABSORPTION BY INSERTED LIQUID SAMPLES A65-15816
- OPTIMUM PEAK POWER FROM GIANT PULSE LASER IN TERMS OF LOSS FACTOR AND POPULATION DENSITY A65-15824
- BACKGROUND GAS PRESSURE EFFECT ON LASER INDUCED ELECTRON EMISSION FROM ZINC AND TANTALUM SURFACES A65-15838
- OUTPUT FREQUENCY QUADRUPLING IN Q-SPOILED NEODYMIUM-IN-GLASS LASER, USING NONLINEAR OPTIC EFFECT A65-15858
- OPTICAL MIXING OF NITROBENZENE RAMAN RUBY LASER LIGHT IN ADP AND OTHER NONLINEAR DIELECTRIC MEDIA A65-15951
- INJECTION DIODE LASER FROM DEGENERATED GALLIUM ARSENIDE WITH NEODYMIUM DOPED LAYER EMITTING AT 8700 ANGSTROMS A65-15995
- ABSORPTION OF 3.39 MICRON HELIUM-NEON LASER EMISSION BY METHANE IN ATMOSPHERE A65-16362
- SPECTROSCOPIC INVESTIGATION OF LASER EXCITED MOLECULAR SPECTRA FROM POWDERED SOLIDS FOR METEOR AND REENTRY PHYSICS A65-16382
- RELATIVE EFFICIENCIES OF SINGLE AND MULTIPLE ELLIPTICAL CAVITIES FOR LASER PUMPING PRESENTED IN GRAPHICAL FORM A65-16401
- ELECTRICAL SWITCHING OF EMISSION DIRECTION OF LASER OSCILLATOR BY INTERNAL DEFLECTION OF LASER BEAM A65-16403
- GAIN DELAY CHARACTERISTICS OF FOUR-LEVEL NEODYMIUM-DOPED PULSED GLASS-LASER OSCILLATOR-POWER AMPLIFIER CHAIN A65-16574
- POLARIZATION EFFECT ON ENERGY DISTRIBUTION AND EFFICIENCY IN DIFFRACTION GRATING OF ATTENUATED LASER LIGHT A65-16581
- GENERATION OF SINGLE FREQUENCY LIGHT USING FM LASER A65-16670
- C W LASER OSCILLATION ON P BRANCH ROTATIONAL TRANSITIONS OF VIBRATION BAND OF NITROUS OXIDE A65-16671
- INTERFERENCE FRINGE VISIBILITY UP TO 120 M OPTICAL PATH DIFFERENCE, USING HELIUM-NEON LASER SOURCE A65-16766
- STIMULATED BRILLOUIN RADIATION IN OFF-AXIS RUBY LASER RESONATOR USING CARBON DISULFIDE CELL, EXAMINING OUTPUT SPECTRUM A65-16811
- NONLINEAR OPTICAL EFFECTS IN CRYSTALLINE AND ISOTROPIC MATERIALS DUE TO INDUCED POLARIZATION THIRD ORDER IN ELECTRIC FIELD STRENGTH, USING GIANT PULSED LASER SOURCE A65-16863
- RARE EARTHS IN OPTICAL MASER MATERIALS, DISCUSSING CHEMICAL INTERACTIONS BETWEEN ACTIVE ION AND HOST LATTICE A65-17052
- THOMSON SCATTERING SPECTRUM OF LASER BEAM FROM EQUILIBRIUM HYDROGEN PLASMA, NOTING EFFECT OF DEBYE LENGTH A65-17151
- I R LASER ACTION IN ARGON II BETWEEN 1 AND 2 MICRONS AND IN 6000 TO 7000 ANGSTROM RANGE A65-17207
- YB3- ER3 GLASS THREE LEVEL LASER ACTION A65-17208
- OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER BY P-N TRANSITIONS TO INCREASE POWER AND DIRECTIVITY OF EMISSION A65-17319
- XENON-KRYPTON LASER EMISSION IN 12 WAVELENGTHS RANGING FROM 2.03 TO 9 MICRONS WITH EXTERNAL AND INNER MIRRORS A65-17353
- LASER BEAM DIVERGENCE AND ENERGY DISTRIBUTION MEASUREMENT, USING WIDE LATITUDE FILM AND THIN CELLULOID MIRROR A65-17432
- COHERENT AND INCOHERENT OUTPUT CURVE OF THREE-LEVEL QUANTUM FREQUENCY CONVERTER A65-17505
- THREE-LEVEL LASER OUTPUT STABILITY EQUATION DERIVED BY NONLINEAR MECHANICS, NOTING LIMIT CYCLE AND OSCILLATION STABILITY PRECONDITION A65-17514
- HEATING AND VAPORIZATION EFFECTS DUE TO HIGH POWER LASER BEAM ABSORPTION AT OPAQUE SURFACES, NOTING ALSO Q-SWITCHED LASERS A65-17663
- CO-60 GAMMA IRRADIATION INDUCED ENERGY OUTPUT INCREASE OF RUBY LASER CRYSTAL A65-17687
- PULSED RUBY LASER OUTPUT MEASUREMENT BY OPTICAL BOLOMETER A65-18017
- INDUSTRIAL APPLICATION OF RUBY AND NEODYMIUM LASERS INCLUDE SUPERHARD MATERIAL MACHINING AND METALLURGY A65-18120

# SUBJECT INDEX

# LASER OUTPUT CONT

- THREE-MIRROR CORNER-CUBE INTERFEROMETER SYSTEM WITH ROTATION INSENSITIVITY TO PRODUCE HIGH CONTRAST LASER FRINGES A65-18217
- DIFFRACTION LOSSES AND FIELD DISTRIBUTIONS AT REFLECTORS OF LOW-LOSS MODES OF SYMMETRIC CONFOCAL LASER RESONATOR A65-18315
- PHOTON ROCKET ENGINE USING PLASMA LASER EMISSION A65-18375
- EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS BY INCLINING GENERATING SAMPLE WITH RESPECT TO INTERFEROMETER AXIS A65-18454
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING TOTAL REFLECTION PRISM A65-18462
- GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM INCIDENT ON PLANE PARALLEL GLASS PLATE OF RESONATOR A65-18555
- EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION A65-18558
- FORWARD BIASED P-N JUNCTION ELECTROLUMINESCENCE THEORY AND APPLICATIONS TO DIODE LASERS A65-18872
- LASER OUTPUT MEASUREMENT BY PHOTOELECTRIC CELL DEVICE, NOTING CALIBRATION ONERA TP 182 A65-19066
- TIME DEPENDENT VARIATION OF RUBY LASER STIMULATED EMISSION INTENSITY A65-19074
- FABRICATION AND TEST OF CONTINUOUS WAVE LASER ACTION FROM DYSPROSIUM IN CALCIUM FLUORIDE EXCITED BY TUNGSTEN LAMP A65-19184
- SEMICONDUCTOR LASER DIGITAL DEVICES FOR GENERAL PURPOSE LOGIC CIRCUITS BASED ON NONLINEAR INTERACTION OF INTENSE OPTICAL SIGNALS A65-19342
- LASER EMISSION FROM N TYPE GALLIUM ARSENIDE CRYSTAL BY FAST ELECTRON EXCITATION, NOTING DOPING AND EMISSION ENERGY A65-19546
- LASER BEAM BEYOND-HORIZON COMMUNICATION BY MEANS OF CLOUD AND HAZE SCATTERING A65-19596
- STIMULATED RAMAN EFFECT OF BENZENE USING RUBY LASER, EXAMINING OUTPUT SPECTRUM, THRESHOLD POWER AND EFFICIENCY AT STOKES LINES A65-19598
- QUASI-CONTINUOUS EMISSION OR REGULAR RELAXATION OSCILLATIONS FROM MANY-ELEMENT RUBY LASER OPERATING IN VERY FEW AXIAL MODES A65-19619
- HELIUM-NEON LASER RADIATION DISPERSION MEASUREMENT IN TRANSITION 3S2-2P4 FOR VARYING MIRROR SPACING A65-19693
- STABILITY AND SOLUTION OF EQUATIONS OF MOTION FOR TRAVELING WAVE INTERACTIONS IN LASERS A65-19726
- ION AND FREE ELECTRON PRODUCTION RATE STUDY IN GAS UNDER LASER BEAM ACTION A65-19727
- INEXPENSIVE SIMPLIFIED CONSTRUCTION OF DC POWERED HELIUM NEON LASER WITH 6328 ANGSTROM OUTPUT A65-19849
- LASER ACTION THEORY IN CRYSTALLINE OPTICAL SOLID, DISCUSSING PROMISING MATERIALS AND MULTIPHONON PROCESSES IMPORTANCE IN LINE WIDTH AND TRANSITION PROBABILITIES A65-19997
- LASER AS THERMAL TOOL IN METAL WORKING PROCESSES EXAMINING PHASE TRANSFORMATION A65-20005
- OPTICAL COHERENT WAVE PROPERTIES SUITABLE FOR LONG DISTANCE LASER COMMUNICATIONS AND COMPARED WITH RADIO WAVE CHARACTERISTICS A65-20006
- GAS DISCHARGE COLLISION LASER EFFICIENCY AND POWER OUTPUT CONSIDERATIONS WITH ATTENTION TO MANGANESE AND LANTHANUM DISCHARGES A65-20062
- ABSORPTION DATA FOR METHANE AND ETHANE, USING HE-NE TUNED LASER SPECTROSCOPY A65-20064
- LASER OSCILLATION IN DECAY OF EXCITED MOLECULES FROM CHEMICAL REACTION, NOTING CHANGE IN THREE ELECTRONIC LEVELS IN MOLECULAR SYSTEM A65-20069
- ATOMIC AND MOLECULAR FLUORESCENCE EXCITED BY PHOTODISSOCIATION, DISCUSSING LINE STRENGTH AND DOPPLER WIDTH A65-20073
- LASER ACTION IN RARE EARTH CHELATES, EMPHASIZING CHEMISTRY AND SPECTROSCOPIC PROPERTIES OF MATERIALS AND PROPERTIES OF LIQUID LASER A65-20074
- CHROMIUM INDUCED LIGHT DISPERSION IN R LINES OF RUBY, NOTING REFRACTION SHIFT IN LASER SPECTRUM A65-20260
- LASER OUTPUT OF XENON-HELIUM MIXTURE AS FUNCTION OF CHARGE DURATION, GAS PRESSURE AND TUBE DIAMETER A65-20263
- CONTINUOUS REGIME OPTICAL GENERATOR OUTPUT, THRESHOLD PUMPING LEVEL, INVERSE POPULATION DENSITY AND INDUCED RADIATION ENERGY A65-20326
- RUBY LASER THRESHOLD PUMPING AND EMISSION ENERGIES RELATED TO TRANSMISSION COEFFICIENT, ROD DIAMETER AND THRESHOLD LEVEL A65-20343
- ATOMIC RELAXATION AND FLUCTUATIONS OF LASER PHOTONS DETERMINED BY ADDING PROBABILITY AMPLITUDES A65-20744
- RADIATIVE REACTION EFFECTS ON GIANT PULSE LASER STABILITY IN ANISOTROPIC MEDIUM A65-20913
- EMISSION SPECTRUM OF RUBY LASER WITH EXTERNAL SPHERICAL MIRRORS IN NONDAMPING INTENSITY FLUCTUATIONS AND QUASI-STEADY GENERATION A65-21041
- EXPERIMENTAL PROCEDURE TO MEASURE PROBABILITY DENSITY AMPLITUDE OF ELECTRIC COMPONENT OF LASER RADIATION FIELD A65-21070
- RUBY LASER OUTPUT RADIATION CHANGE DUE TO PHTHALOCYANINE SOLUTIONS PLACED IN RESONATOR CAVITY A65-21071
- OPTICAL COMMUNICATION IN SPACE USING LASERS, EMPHASIZING NATURAL LIMITATIONS, E.G., ATMOSPHERIC ABSORPTION A65-21077
- SPECTROSCOPIC DATA ON ABSORPTION, SPONTANEOUS FLUORESCENCE AND STIMULATED EMISSION IN ACTINIDES, TRANSITION METAL AND SEMICONDUCTOR LASER MATERIAL A65-21168
- SUPPRESSING PULSED LASER SPIKING BY PROVIDING EQUILIBRIUM PHOTON DENSITY AS THRESHOLD IS REACHED, NOTING CASE OF RUBY LASER A65-21300
- REFLECTED RADIATION OF Q-SPOILED RUBY LASER FROM EXPLORER XXII A65-21306
- HELIUM-NEON LASER PREAMPLIFIER SYSTEM FOR VERY HIGH GAIN TRANSITION AT 3.39 MICRON WAVELENGTH A65-21335
- ELECTROLUMINESCENCE OF ZINC DIFFUSED DIODES IN FORWARD AND REVERSE BIAS, OBSERVING EMISSION SPECTRA AND LASING ACTION IN NEAR-EDGE LINE A65-21617
- AUTOMATIC FEEDBACK CONTROL FOR LONG-TERM FREQUENCY STABILIZATION OF HE-NE LASER AT CENTER FREQUENCY OF ATOMIC RESONANCE A65-21620

CONTINUOUS LASER ACTION IN NEODYMIUM DOPED CALCIUM  
MOLYBDATE AT ROOM TEMPERATURE A65-21627

SINGLE-ATOM COHERENCE EFFECTS IN MEASUREMENT OF  
SPONTANEOUS EMISSION LINEWIDTHS IN HIGH-GAIN NEON  
LASER A65-21654

POLARIZED LASER RADIATION WITH RELATION BETWEEN  
INTENSITY AND DIPOLE MOMENT OF ANISOTROPY AND  
PUMPING POWER A65-21805

LASER FUTURE POSSIBILITIES AND APPLICATION  
CONSIDERING OPTICALLY PUMPED SOLIDS,  
SEMICONDUCTORS AND ANCILLARY EQUIPMENT A65-21954

CARBON MONOXIDE AND DIOXIDE VIBRATIONALLY INDUCED  
IR EMISSION WITH POSSIBLE APPLICATIONS TO  
CONTINUOUS LASER EMISSION A65-22463

DETERMINATION OF ATTENUATING FILTERS REQUIRED FOR  
EYE PROTECTION AGAINST LASER RADIATION A65-22614

DATA ON LASER MATERIALS REFERENCED TO MAY 1964  
INCLUDING LASER EMISSION LINES AND LASER  
PERFORMANCE PARAMETERS A65-22616

POWER OUTPUT AND THRESHOLD POWER FOR CONTINUOUS  
WAVE NEODYMIUM-CALCIUM TUNGSTATE LASER IN RANGE OF  
DRY ICE TO ROOM TEMPERATURE A65-22619

GAS MIXTURES AND PRESSURES FOR OPTIMUM OUTPUT  
POWER OF RF-EXCITED HELIUM-NEON GAS LASERS AT  
632.8 NM A65-22620

SIMPLE SINGLE MODE HELIUM-NEON LASER WHOSE OUTPUT  
IS SUFFICIENT FOR INTERFEROMETRIC METROLOGY A65-22621

RATE EQUATION SOLUTIONS FOR Q-SPOILED AND PULSED  
TRANSMISSION MODE / PTM/ OPERATION OF THREE-LEVEL  
LASER A65-22933

ROCKET MISSILE ATTITUDE SENSING DURING EARLY  
LAUNCH PHASE USING POLARIZED LASER BEAMS  
TRANSMITTED FROM GROUND STATION A65-23619

PRODUCTION OF ION VELOCITIES OVER 4 KM/SEC BY  
FOCUSED RUBY LASER MAKES PRACTICAL APPLICATION IN  
DIRECT THRUSTORS AND AS PLASMA SOURCE IN  
ACCELERATOR TYPE THRUSTORS A65-23626

OPTIMUM LASER CAVITY STRUCTURES USING MATRIX  
CALCULATIONS BASED ON GEOMETRICAL OPTICS  
APPROXIMATION A65-23846

PHYSICAL CONDITIONS FOR OBTAINING LASER EFFECT IN  
P-N JUNCTION AND TECHNOLOGY IN CONSTRUCTING LASER  
DEVICES A65-23847

DEVICES OBTAINING INFORMATION FROM MODULATED LASER  
BEAMS INCLUDING PHOTOEMISSIVE DETECTORS AND SOLID  
STATE PHOTODETECTORS A65-23964

OPTICAL MASER THEORY INCLUDING OSCILLATORS,  
RADIATION EMISSION, QUANTUM MECHANICS, ETC A65-24004

INTERNAL LOSSES EFFECT ON RADIATION POWER IN LASER A65-24058

VISUAL PERCEPTION OF INTENSE COHERENT IR  
RADIATION FROM GAS LASER A65-24083

PERFORMANCE CHARACTERISTICS OF GALLIUM ARSENIDE  
AND MIXED-CRYSTAL INJECTION LASERS SURPASS ALL  
OTHER LASERS IN EFFICIENCY AND CW POWER OUTPUT A65-24130

STIMULATED EMISSION IN SILICATE GLASS LASER  
CONTAINING NEODYMIUM A65-24189

HIGH INTENSITY LOW VOLTAGE DISCHARGE RESULTING  
FROM RUBY LASER BEAM FOCUSING ON TITANIUM HYDRIDE  
TARGET A65-24282

AUTOMODULATION OF EMISSION FROM SOLID STATE LASER

A65-24809

HELIUM-NEON LASER MULTIBEAM GENERATION IN GAS  
DISCHARGE TUBE, USING SPHERICAL MIRRORS AND  
TAPERED PLATES A65-24824

POLARIZED LASER RADIATION WITH RELATION BETWEEN  
INTENSITY AND DIPOLE MOMENT OF ANISOTROPY AND  
PUMPING POWER A65-24857

LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO  
DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF  
SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS A65-24879

STATISTICAL DISTRIBUTION OF ARRIVAL ANGLE, SPOT  
LOCATION, AMPLITUDE, ETC, OF LASER BEAM TRAVERSING  
TURBULENT ATMOSPHERE A65-24931

SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-24951

LASER OUTPUT SPIKING ELIMINATION USING KERR CELL  
CONTROLLED BY FEEDBACK CIRCUIT A65-24954

TANTALUM ELECTRON INDUCED THERMIONIC EMISSION AS  
RESULT OF LASER BEAM BOMBARDMENT A65-24956

LASER GIANT PULSING USING SATURABLE ABSORBER  
INSIDE CAVITY AS FAST SWITCH A65-24960

INDIUM ARSENIDE DIODE SPONTANEOUS AND LASER  
ELECTROLUMINESCENCE IN MAGNETIC FIELDS A65-24961

RESONANCE OSCILLATION IN RUBY LASER EMISSION  
STUDIED BY FABRY-PEROT MULTIPLEX ETALON AS  
FUNCTION OF RESONATOR PROPERTIES A65-24976

QUANTUM THEORETICAL ANALYSIS OF LASER BEAM  
FLUCTUATIONS AND OF LIGHT BEAT EXPERIMENTS WITH  
TWO LASERS A65-25059

LASER SYSTEM COHERENCE PROPERTIES OF STATISTICAL  
OPERATOR R IN LIGHT FIELD, USING SCHROEDINGER  
EQUATION ASSUMING GLAUBER STATE A65-25265

ELECTROMAGNETIC FIELD AND SECOND OPTICAL HARMONIC  
GENERATED IN LASER RESONATOR AS TWO INTERDEPENDENT  
PROCESSES A65-25271

LASER OSCILLATOR WITH EXTERNALLY APPLIED SIGNAL  
EMPHASIZING PUSHING-PULLING EFFECTS, POWER GAIN  
AND NATURAL OSCILLATION QUENCHING CONDITIONS A65-25861

GIANT PULSE LASER USED FOR PRODUCTION OF PARTICLES  
WITH ENERGIES HIGHER THAN TEN BILLION EV A65-25877

SINGLE RESONATOR REFLECTION AMPLIFIER ANALYSIS IN  
TERMS OF SCATTERING MATRIX DESCRIPTION OF OPTICAL  
RESONATOR A65-25885

COHERENT HIGH POWER PULSES FROM OPTICALLY PUMPED  
Y AG-ND LASER BY Q-SWITCHING FROM MIRROR  
ROTATION A65-26003

RESONANCE RADIATION TRAPPING BETWEEN LOWER LASER  
LEVEL AND ION GROUND STATE AS MECHANISM FOR  
QUENCHING AND RING-SHAPED BEAM FORMATION IN ION  
LASERS A65-26004

CONTINUOUS LASER EMISSION DUE TO VIBRATIONAL  
TRANSITIONS IN CARBON DIOXIDE AND NITROUS OXIDE  
MIXTURES EXCITED BY HF SOURCE A65-26292

FIRST ORDER RAMAN SCATTERING MEASUREMENT IN  
SILICON USING 6328-ANGSTROM OUTPUT OF HELIUM-NEON  
LASER A65-26457

LIGHT DIFFRACTION BY GRATING DUE TO FARADAY AND  
KERR EFFECT IN ELECTROMAGNETIC FIELD OF LASER  
BEAM A65-26582

KINETIC EQUATION THEORY APPLIED TO STEADY STATE

# SUBJECT INDEX

# LASER OUTPUT CONT

- LASER RADIATION DUE TO BAND-BAND TRANSITION IN SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS  
A65-26694
- PHOTOMULTIPLIER AS LASER MONITOR EVALUATED IN TERMS OF PROBABILITY DENSITY FUNCTION  
A65-26828
- PHYSICAL PRINCIPLES OF LASERS AND APPLICATION IN STUDYING RADIATION AND MATTER INTERACTION  
A65-26933
- MASER AND LASER PROPERTIES INCLUDING RADIATION FIELD AND MASER MEDIA, NOTING MOLECULAR AMPLIFICATION CENTERS AND ENGINEERING PROBLEMS  
A65-26935
- NOISE BEHAVIOR OF POTENTIAL MINIMUM OF TRAVELING WAVE TUBES AND REDUCTION FACTOR FOR SHOT NOISE DETERMINED, USING LASERS  
A65-26936
- NINE ADDITIONAL LASER LINES IN PULSED XENON DISCHARGE UNDER CONDITIONS THAT DO NOT PRODUCE PREVIOUSLY OBSERVED LINES  
A65-26953
- PULSED AND CONTINUOUS WAVE LASER OPERATION OF THULIUM ION DOPED ERBIUM OXIDE WHICH PROVIDES PUMPING MECHANISM BY MEANS OF ENERGY TRANSFER  
A65-26955
- INTERFEROMETER TUNING EFFECT ON ZEEMAN BEAT FREQUENCY IN RADIATION OF HELIUM-NEON LASER WITH APPLIED MAGNETIC FIELD  
A65-26956
- LASER BEAM-GAS INTERACTION INDUCED DISCHARGE STUDIED FOR THRESHOLD, BREAKDOWN AND EMITTED LIGHT CHARACTERISTICS  
A65-27084
- GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM INCIDENT ON PLANE PARALLEL GLASS PLATE OF RESONATOR  
A65-27148
- EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION  
A65-27151
- LENSSLESS PHOTOGRAPHY USING LASERS AND HOLOGRAM/ INTERFERENCE PATTERNS BETWEEN REFERENCE WAVE AND WAVES SCATTERED BY RECORDED OBJECT/PRODUCING THREE-DIMENSIONAL IMAGES  
A65-27196
- U V ION LASER TRANSITIONS IN INERT GASES, OXYGEN AND NITROGEN BETWEEN 2300 AND 4000 ANGSTROMS, SHOWING RELATIONSHIP BETWEEN GAIN AND TUBE DIAMETER  
A65-27334
- Q-SWITCHING OF ND LASER USING POLYMETHINE DYE IN METHYL ALCOHOL SOLVENT  
A65-27533
- GIANT LASER EMISSION PULSES IN NEODYMIUM ACTIVATED GLASS ROD BY VARYING CAVITY Q WITH QUINOLINE SOLUTION OF POLYMETHINE DYE  
A65-27554
- HIGH QUANTUM EFFICIENCY IN NARROW BAND TRIVALENT RARE EARTH DOPED QUANTUM COUNTER ACHIEVED BY LASER PUMPING  
A65-27604
- COHERENCE PROPERTIES OF INTERACTING SYSTEM OF RADIATION AND MATTER EXHIBITING LASER-LIKE BEHAVIOR, NOTING SELF-CONSISTENT-FIELD APPROXIMATION / SCFA/ USE FOR MANY-BODY EFFECTS  
A65-27725
- BEAM DIVERGENCE ANGLE OF SINGLE TEM MODE NE- HE LASER OUTPUT AT 0.63 MICRONS  
A65-27739
- NONLINEAR THEORY OF LASER NOISE WITH CORRELATION FUNCTIONS DERIVED FROM DISTRIBUTION FUNCTIONS OBTAINED BY FOKKER- PLANCK EQUATION  
A65-27759
- SENSITIVITY OF COHERENT OPTICAL HETERODYNE RECEIVER IN DETECTING LASER RADIATION REFLECTED FROM DIFFUSE SURFACE  
A65-28005
- EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS BY INCLINING GENERATING SAMPLE WITH RESPECT TO INTERFEROMETER AXIS  
A65-28083
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING TOTAL REFLECTION PRISM  
A65-28091
- MULTICHANNEL PHOTOELECTRIC SPECTRUM ANALYZER WITH KERR CELL GATING RECORDS SPECTRUM OF LASER LIGHT SCATTERED FROM SINGLE GIANT PULSE IN PLASMA  
A65-28203
- SYSTEMS ANALYSIS OF LASERS VS MICROWAVES FOR MARS-TO- EARTH COMMUNICATIONS IN 1970  
A65-28248
- ACQUISITION AND REACQUISITION IN SPACECRAFT- SPACECRAFT AND SPACECRAFT-TO- EARTH COMMUNICATIONS USING LASER SYSTEMS  
A65-28249
- OPTICAL BEAM SCANNING AND LASER OUTPUT MODULATION BY MEANS OF ULTRASONIC CELL BUILT AROUND FOCUSING CYLINDRICAL SECTION TRANSDUCER  
A65-28419
- QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION  
A65-28487
- TIME DEVELOPMENT OF OUTPUT INTENSITY OF HE- NE LASER AFTER QUENCHING BY PUMPING PARTICLES INTO LOWER NEON LASER STATE  
A65-29075
- LASER ACTION IN ALLOYED GALLIUM ARSENIDE JUNCTION DIODE SUBMERGED IN LIQUID NITROGEN  
A65-29198
- COHERENT LIGHT DIFFRACTION BY MICROWAVE SOUND IN TRANSPARENT CRYSTALS  
A65-29265
- SINGLE MODE LASER EFFICIENCY AT HIGH PUMP LEVELS AS FUNCTION OF PUMPING RATE AND LASER LENGTHS TAKING INTO ACCOUNT MODE SHAPE CHANGES  
A65-29505
- TRANSITION PROBABILITIES FOR AR II LASER LINES COMPARED WITH PREVIOUS THEORETICAL AND EXPERIMENTAL DATA  
A65-29799
- OPTICAL TRACKING OF SATELLITES EQUIPPED FOR GEODETIC TRIANGULATION, USING GROUND LASER BEAMS  
A65-29936
- LASER OSCILLATION IN GASEOUS IONS, TABULATION OF WAVELENGTHS, CLASSIFICATIONS AND REFERENCES FOR 230 ION LASER TRANSITIONS  
A65-30343
- LONGITUDINAL MODE SELECTION IN GIANT PULSE LASER RESULTING IN SINGLE-MODE OUTPUT  
A65-30345
- REABSORPTION AS DOMINANT LOSS MECHANISM FOR BOTH INCOHERENT AND COHERENT RADIATION IN GALLIUM ARSENIDE LUMINESCENT DIODE  
A65-30347
- OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER BY P-N TRANSITIONS TO INCREASE POWER AND DIRECTIVITY OF EMISSION  
A65-30372
- CATHODOLUMINESCENT PHOSPHORS AS LIGHT SOURCE FOR LASERS, REDUCING HEAT LIMITATIONS AND ELIMINATING INTERNAL STRESSES CAUSED BY THERMAL GRADIENTS  
A65-30436
- RECOMBINATION RADIATION FROM GALLIUM ANTIMONIDE P-N JUNCTIONS, OBSERVING STIMULATED EMISSION AND LASER ACTION  
A65-30572
- OXYGEN AS CAUSE OF SCATTERING AND CONVERSION OF IMPURITIES TO HIGHER VALENCE STATE IN CALCIUM FLUORIDE LASER SYSTEM  
A65-30800
- NOISE IN GAS LASERS AND LASER DETECTORS, AMPLIFIERS AND OSCILLATORS, NOTING HELIUM-NEON LASER OSCILLATION  
A65-31002
- PHOTOGRAPHIC STUDY OF Q-SWITCHED LASER BEAM PROPAGATING OVER 10-MILE PATH  
A65-31044
- EXPERIMENTAL PROCEDURE TO MEASURE PROBABILITY DENSITY AMPLITUDE OF ELECTRIC COMPONENT OF LASER RADIATION FIELD  
A65-31235
- RUBY LASER OUTPUT RADIATION CHANGE DUE TO

PHthalocyanine SOLUTIONS PLACED IN RESONATOR CAVITY A65-31236

EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF FORBIDDEN BAND IN GALLIUM ARSENIDE A65-31307

HELIUM-NEON LASER OUTPUT CHARACTERISTICS AS FUNCTION OF LASER PARAMETERS A65-31375

TIME-VARIATION AND SPONTANEOUS EMISSION FROM HE-HG DISCHARGE OF 6149 ANGSTROM LASER TRANSITION A65-31451

LASER POWER DENSITY MEASURED WITH REDUCED ABSORPTION OF LIGHT BY METHYLENE BLUE, USING HE-NE- CW LASER A65-31455

SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER RADIATION, DETERMINING TEMPERATURE OF PLASMA PRODUCED NEAR FOCUS A65-31705

DISPERSION OF 1.15 MICRON HE- NE LASER LINE RESULTING FROM NEON ABSORPTION TRANSITION A65-31762

BEAM DIVERGENCE ANGLE OF SINGLE TEM MODE NE- HE LASER OUTPUT AT 0.63 MICRONS A65-31844

LASER CONFIGURATIONS, PERFORMANCE FEATURES AND LIMITATIONS DISCUSSING HE- NE, ION AND SOLID STATE LASERS A65-31881

EVAPORATED CADMIUM SULFIDE THIN FILMS PROCESSED TO ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING LASER-INDUCED ELASTIC VIBRATION A65-31942

CALCULATION OF RADIATION INTENSITY OBTAINED FROM LASER WITH HOMOGENEOUS LINE BROADENING GENERALIZED FOR ARBITRARILY LARGE LOSS FRACTION PER PASS A65-32219

GAS EFFECTS PRODUCED BY PULSED LASER BEAM IN BALLISTIC TORSIONAL PENDULUM PHOTOMETER, NOTING DEFLECTION DUE TO PHOTON MOMENTUM EXCHANGE A65-32229

FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS SYSTEMS, PRIMARILY LIGHT ABSORPTION AND ATMOSPHERIC SCATTERING A65-32353

ELECTROSTATIC IMAGE CONVERTER CAMERA USED IN PLASMA AND LASER RESEARCH FOR HIGH SPEED WRITING A65-32585

LASER RANGEFINDER DEVICE PROVIDES FAST AND ACCURATE RANGE OF NONCOOPERATIVE TARGETS OPERATING ON RADAR PRINCIPLE A65-32586

OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER AS AIRCRAFT ALTIMETER TO ELIMINATE SPURIOUS ECHOES A65-32588

GAS PRESSURE AND TUBE DIAMETER EFFECT ON OPTICAL GAIN OPERATING CHARACTERISTICS OF XENON LASER AMPLIFIER A65-32743

SIMULTANEOUS LASER OSCILLATION OBSERVED AT 6943 AND 6929 ANGSTROM WAVELENGTHS IN NORMAL AND Q-SPOILED OPERATION OF RUBY LASER A65-32748

KINETIC EQUATION THEORY APPLIED TO STEADY STATE LASER RADIATION DUE TO BAND-BAND TRANSITION IN SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS A65-32952

LASER ACTION IN SECOND POSITIVE BAND SYSTEM OF MOLECULAR NITROGEN, OBSERVING SATURATION OF TRANSITION A65-33049

C W HIGH POWER OPERATION OF NITROGEN-CARBON DIOXIDE LASER OSCILLATING ON P-BRANCH ROTATIONAL TRANSITIONS OF VIBRATIONAL BAND OF CARBON DIOXIDE A65-33055

EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER

WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF FORBIDDEN BAND IN GALLIUM ARSENIDE A65-33354

TIME RESOLVED SPECTRA FOR PULSE OPERATED GALLIUM ARSENIDE LASER DIODES A65-33372

INTERACTION BETWEEN OPTICAL MASER MEDIUM AND ELECTROMAGNETIC PULSE PROPAGATING IN IT, DISCUSSING AMPLIFIER EQUATIONS AND STEADY STATE PULSE / SSP/ IN AND OUT OF RESONANCE A65-33374

ATMOSPHERIC TURBULENCE EFFECT ON OPERATION OF DUAL-POLARIZATION FM LASER COMMUNICATION SYSTEM A65-33377

LASER OSCILLATION IN VISIBLE REGION FROM PULSED COLD CATHODE DISCHARGE IN IONIZED S AND P A65-33379

OPTICAL GAIN AND LOSSES OF GA AS LASER OF EPITAXIAL AND DIFFUSED TYPE A65-33380

EFFECT OF NONUNIFORM SPATIAL INTERACTION BETWEEN MODES ON TEMPORAL AND SPATIAL OUTPUT OF RUBY LASER A65-33415

CRYSTALLINE CALCITE USED AS DICHROIC POLARIZER IN IR REGIONS, LASER RADIATION, ZEEMAN EFFECT AND NOISE PROPERTIES MEASUREMENTS, ETC A65-33419

OSCILLATION CHARACTERISTICS OF RUBY LASER WITH EXTERNAL MIRRORS OF LARGE SPACING A65-33517

TIME RESOLVED SPECTROSCOPY OF MERCURY-HELIUM DISCHARGE AND 6150 ANGSTROM LASER OSCILLATION, EXAMINING METASTABLE ATOM STATE A65-33518

GIANT RUBY LASER PULSE PRODUCTION FROM RAPID SATURATION OF DYE ABSORBER SOLUTION IN OPTICAL CAVITY BY SINGLET-SINGLET TRANSITIONS A65-33521

ACQUISITION, TRACKING AND BEAM POINTING FOR OPTICAL COMMUNICATION IN SPACE AIAA PAPER 64-420 A65-33536

OPTICAL ANALOG COMPUTER TRANSPOSING VARIABLE INPUTS INTO SPATIAL DIMENSIONS, USING LASER AS LIGHT SOURCE FOR ANTENNA MODELING AND SPECTRUM ANALYSIS A65-33770

TIME PARAMETERS OF POWERFUL LASER MEASURED WITH GA AS PHOTODIODE, NOTING TIME CONSTANT AND TIME RESOLUTION OF PHOTODIODE A65-34552

TWO BREWSTER-TYPE LASERS IN OSCILLATOR-AMPLIFIER CONFIGURATION USED TO MEASURE LASER GAIN IN XENON-KRYPTON DISCHARGE A65-34610

TIME CORRELATION BETWEEN LASER PULSES AND LASER-INDUCED ELECTRON EMISSION FROM METALLIC SURFACES A65-34616

RELATION BETWEEN 600 ANGSTROM EMISSION BAND OF HELIUM MOLECULE AND IMPRISONMENT OF NEON RESONANCE LINES MEASURED TO SHOW EFFECT ON HELIUM-NEON LASER OPERATION A65-34662

THRESHOLD INTENSITY OF 8400 ANGSTROM LIGHT FROM GALLIUM ARSENIDE LASER DIODE AND EYE DAMAGE A65-34663

FLUORESCENCE FROM CADMIUM SULFIDE EXCITED BY RUBY LASER COMPARED WITH PHOTOCONDUCTIVITY INDUCED BY ORDINARY GREEN LIGHT TO SUPPORT DOUBLE PHOTON ABSORPTION MECHANISM A65-34665

ELECTRON DENSITY AND COLLISION FREQUENCY MEASUREMENTS IN TRANSIENT OSCILLATION OF IR AND VISIBLE HELIUM-NEON LASERS TO DETERMINE RELATIONSHIP BETWEEN OSCILLATIONS AND PLASMA PARAMETERS A65-34806

VISUAL PERCEPTION OF INTENSE COHERENT IR

## SUBJECT INDEX

## LASER OUTPUT CONT

- RADIATION FROM GAS LASER A65-34904
- WHITE LIGHT EMISSION WHEN PULSED LASER BEAM FOCUSES ON TARGETS IS MAINLY DUE TO TEMPERATURE RADIATION A65-34957
- LASER EXCITATION IN FREON AND RARE GAS MIXTURES BASED ON DISSOCIATIVE EXCITATION PROCESS AND QUENCHING ACTION OF SOME GASES A65-35043
- EMISSION CHARACTERISTICS OF Q-SWITCHED RUBY LASER WITH SATURABLE ABSORBER A65-35053
- MODE LOCKING EFFECTS IN INTERNALLY KDP MODULATED RUBY LASER A65-35063
- U V RADIATION STIMULATED EMISSION IN OPTICALLY PUMPED POTASSIUM BROMIDE CRYSTALS USEFUL FOR LASER EMISSION WHICH IS CONSISTENT WITH POPULATION INVERSION EXCITON SCHEME A65-35069
- ACTIVE AND PASSIVE Q-SWITCHES FOR INCREASING STORED PUMPING ENERGY OF LASERS AND INHIBITING RESONANCE FOR SUBSEQUENT PEAK LASER EXCITATION AND DISCHARGE A65-35118
- DESIGN AND CONSTRUCTION OF STABLE SINGLE FREQUENCY RF EXCITED HE- NE LASER AT 6328 ANGSTROMS A65-35358
- LASER EMISSION WITH VARIABLE RESONATOR LOSSES, CONSIDERING RELATIVELY LOW INITIAL OVERPOPULATION A65-35784
- EFFECTS OF RESONATOR LENGTH AND MIRROR TRANSPARENCY AND ALIGNMENT UPON DYNAMIC AND STATIC CHARACTERISTICS OF RUBY LASER WITH MODULATED Q-FACTOR A65-35786
- RUBY LASER NOISE RADIATION CONSISTING OF INCREASED LUMINESCENCE AND Laterally DISPERSED GENERATION DETERMINED FROM ENERGY LEVEL POPULATIONS A65-35863
- CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY LASER A65-35866
- GAS LASER EMISSION SOLUTION BY DETERMINING EMISSION FIELD DENSITY DEPENDENCE ON RESONATOR PARAMETERS, RELAXATION CHARACTERISTICS AND ATOM EXCITATION IN GAS DISCHARGE PLASMA A65-35868
- LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION A65-35875
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM, NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION A65-35877
- INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY AFTER LEAVING LASER AND AFTER FOCUSING WITHIN LENS, NOTING OPTIMUM FOCUSING CONDITIONS A65-36050
- OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF SOLID STATE LASER AND COMPENSATION VIA LENS IN RESONATOR A65-36051
- ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION DURING OPTICAL PUMPING, NOTING RELATION BETWEEN ENERGY ABSORPTION AND POPULATION INVERSION A65-36055
- POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR A65-36058
- LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS A65-36356
- MODE DEGENERACY-DIPS ON OUTPUT OF HE- NE LASER FOR CERTAIN CRITICAL COMBINATION OF MIRROR CURVATURES AND SEPARATION A65-36703
- PHOTON TRANSPORT AND POPULATION INVERSION IN
- ACTIVE MEDIUM WITH PUMPING EFFECT, CONSIDERING INTENSE BEAM INCIDENCE AND RUBY LASER A65-36712
- WIDTH OF LINES EMITTED BY LASER MODELS FTD-TT-64-841 N65-14217
- USE OF REFRACTIVE INDEX VARIATION CAUSED BY PROPAGATION OF ULTRASONIC WAVES IN LASER FEEDBACK INTERFEROMETER TO CONTROL LASER OUTPUT C-920083-12 N65-15207
- LASER BEAM COMMUNICATION BETWEEN DEEP-SPACE VEHICLE AND EARTH TRACKING STATION - CLOSED LOOP SYSTEM AND LEAD ANGLE COMPUTATIONS FOR TARGET MOTION COMPENSATION NASA-CR-60699 N65-16811
- OUTPUT AND DIVERGENCE MEASUREMENTS FOR Q-SWITCHED KERR CELL LASER REPT.-1579-18 N65-16819
- ENERGY OUTPUT INCREASE OF RUBY LASER CRYSTAL SYSTEMS BY NUCLEAR ENERGY, LASER CRYSTAL GROWTH, AND SURFACE FINISH DEVELOPMENT AD-455571 N65-17595
- GAMMA RADIATION EFFECT ON ENERGY OUTPUT OF RUBY LASER CRYSTALS N65-17596
- SPECTRAL LINE WIDTH NARROWING OF PULSED TRAVELING WAVE RUBY LASER OUTPUT AD-610865 N65-22139
- RUBY LASER WITH VIBRATING MIRROR FOR STUDY OF TEMPORAL OUTPUT MEASUREMENTS N65-22759
- RADIATION DIVERGENCE MEASUREMENT IN HELIUM-NEON LASERS WITH CONFOCAL RESONATORS AND SPHERICAL REFLECTORS N65-24550
- EFFECT OF LASER OPERATION PARAMETERS USING NEODYMIUM DOPED BORATE GLASS ON THRESHOLD AND OUTPUT ENERGY R-1748 N65-25782
- STUDY OF PARAMETERS OF HIGH GAIN 2.026 MICRON XENON-HELIUM LASER TO OPTIMIZE POWER OUTPUT AND EFFECT OF TUBE DIAMETER ON SMALL SIGNAL GAIN WRE-PAD-104 N65-28901
- REPETITIVE HIGH POWER PULSES OBTAINED BY Q-SWITCHING OF NEODYMIUM-LOADED YTTRIUM ALUMINUM GARNET LASER CR-6 N65-30870
- SPECTROSCOPY OF HIGH POWER GAS LASER EMISSION IN VISIBLE SPECTRUM FROM CW ARGON, KRYPTON, XENON, AND MERCURY-HELIUM LASERS GPR-3 N65-31202
- LASER CAVITY ANALYSIS, THRESHOLD MEASUREMENTS, FREQUENCY DISTRIBUTION, MODE DENSITY, AND SPIKING STRUCTURE AFCL-65-481 N65-32298
- LASER ACTION BY ELECTRON BEAM PUMPING - LITERATURE SURVEY NOLTR-65-95 N65-33401
- PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER A66-10262
- FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK SHOCK WAVE IN LASER BEAM A66-10263
- RUBY LASER OUTPUT EXHIBITING REGULAR SPIKES A66-10324
- FOCUSED LASER AS ACCELERATING CAVITY FOR CYCLIC PARTICLE ACCELERATOR A66-10328
- PEAK POWER TRANSIENTS OF NEAR CONFOCAL HELIUM-NEON LASER WORKING AT 6328 ANGSTROMS ON PULSED DISCHARGE BASIS A66-10329
- SELF-LOCKED GAS LASER MODE DEPENDENCE ON CAVITY

- LENGTH AND POSITION OF LASER MEDIUM IN CAVITY  
A66-10347
- LASER TRANSITION IDENTIFICATION IN ELECTRON BEAM  
PUMPED GALLIUM ARSENIDE, PRIMARILY ON  
CONCENTRATION OF SHALLOW DONORS AND ACCEPTORS  
A66-10348
- ELECTRON BEAM PUMPING OF NOBLE GAS ION LASER  
A66-10350
- LASER OSCILLATION INCREASE IN EFFICIENCY IN  
NEODYMIUM DOPED GLASS PRODUCED THROUGH ENERGY  
TRANSFER  
A66-10352
- GALLIUM ARSENIDE INJECTION LASER FOR PROLONGED  
OPERATION AT LIQUID NITROGEN TEMPERATURES  
A66-10369
- ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION  
INVERSION IN LEVELS OF OPTICAL TRANSITION  
A66-10448
- LASER WITH DIFFRACTION LIMITED RADIATION PATTERN  
A66-10450
- BREAKDOWN OF GASES UNDER INFLUENCE OF LASER SPARK  
PHENOMENA WITH SUBSEQUENT ABSORPTION OF LASER  
RADIATION AND GAS HEATING  
A66-10646
- CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER  
A66-10704
- NONLINEAR INTERACTION OF OSCILLATIONS OF TWO TYPES  
IN LASER DOES NOT AFFECT STATIONARY OPERATION WHEN  
OSCILLATIONS ARE SUFFICIENTLY APART IN BAND  
A66-10724
- AERODYNAMIC AND HEAT TRANSFER MEASUREMENTS USING  
INTERFEROMETER WITH CONTINUOUS WAVE LASER AS  
SOURCE  
A66-10849
- THERMAL LIMITATIONS ON CAPABILITIES OF GALLIUM  
ARSENIDE P-N JUNCTION LASERS  
A66-10895
- TWO-DIMENSIONAL LASER DEFLECTION USING FOURIER  
OPTICS  
A66-10897
- CARRIER FREQUENCY STABILIZATION OF FM LASER WITH  
RESPECT TO CENTER OF ATOMIC GAIN PROFILE, USING  
SMALL DISTORTION PRESENT IN LASER OSCILLATION  
A66-10966
- LASER-ACTION THRESHOLD IN ELECTRON-BEAM EXCITED  
GALLIUM ARSENIDE AND EFFECT OF TEMPERATURE AND  
DOPING  
A66-10971
- U V AND VISIBLE LASER OSCILLATIONS IN FLUORINE,  
PHOSPHORUS AND CHLORINE ATOMS IN PULSED CHLORINE,  
PHOSPHORUS FLUORIDE AND SULFUR FLUORIDE GAS  
DISCHARGES  
A66-10972
- SHARPLY DIRECTIONAL COHERENT RADIATION GENERATION  
BY SYNCHRONIZED LASERS OR MULTIMIRRORED RESONATOR  
OF SINGLE LASER  
A66-11007
- KINETIC EQUATION OF LASER OPTIMUM EMISSION,  
DETERMINING PUMPING EFFICIENCY, VALUE OF LOSSES IN  
SPECIAL MODES, ETC  
A66-11058
- CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION  
A66-11188
- METALLIC PLASMA TUBE FOR ION LASERS ALLOWS THEM TO  
RUN AT HIGHER CURRENT DENSITIES THAN WITH CERAMIC  
TUBES  
A66-11373
- PRESSURE DEPENDENCE OF OUTPUT OF HELIUM-NEON  
GASEOUS LASER IN HIGH PRESSURE RANGE  
A66-11375
- SECOND HARMONIC LIGHT GENERATION, STRESSING  
SATURATION EFFECTS OCCURRING AT HIGH LASER POWER  
LEVELS, SOLVING NONLINEAR COUPLED MAXWELL  
EQUATIONS  
A66-11443
- QUANTUM-ELECTRONIC CROSS-MODULATION EFFECT NOTED  
WHILE MONITORING IR LASER INTERFEROMETRIC FRINGES  
A66-11449
- LASER TRANSITION IN VIBRATIONAL STATE OF GROUND  
ELECTRONIC STATE OF CN FROM ROTATIONAL LEVEL 8 TO  
7 WITH POPULATION INVERSION AS RESULT  
A66-11451
- LASER APPLICATION PROBLEMS IN INTERFEROMETRY,  
RADAR AND HOLOGRAPHY INCLUDING MECHANICAL  
STABILITY, NOISE SUPPRESSION, DIRTY LASER BEAM  
RESTORATION, ETC  
A66-11454
- DEVELOPMENT IN U.S. OF LASER APPLICATION WITH  
TABLE INCLUDING GOVERNMENT SUPPORTED PROGRAMS IN  
PHOTOGRAPHY, DATA PROCESSING, RADAR, ETC  
A66-11455
- LINEAR COEFFICIENT OF AMPLIFICATION OF CARBON  
DIOXIDE SUBJECTED TO HF EXCITATION FIELD FOR  
LASER EMISSION  
A66-12003
- CURRENT STATUS OF THEORETICAL AND EXPERIMENTAL  
STUDIES OF VARIANT OF RAMAN EFFECT ENCOUNTERED IN  
SCATTERING OF LASER LIGHT  
A66-12065
- QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION  
AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION  
A66-12086
- LOSSLESS CONVERSION OF PLANE LASER WAVE TO PLANE  
WAVE OF UNIFORM IRRADIANCE, NOTING PLANOASPHERIC  
LENSES METHOD AND ABERRATED LENS SYSTEM  
A66-12204
- GAIN AND BANDWIDTH NARROWING IN REGENERATIVE  
HELIUM-XENON LASER AMPLIFIER  
A66-12308
- BRILLOUIN SCATTERING IN LIQUIDS EXAMINING  
VELOCITY, FREQUENCY AND LIFETIME OF THERMALLY  
EXCITED HYPERSONIC SOUND WAVES, USING LASER LIGHT  
SOURCES  
A66-12422
- GA AS OPTICALLY COUPLED TRANSISTOR STRUCTURE WITH  
LASING EMITTER  
A66-12442
- CUT-OFF OF RUBY LASER EMISSION BY PULSED ELECTRON  
AND BREMSSTRAHLUNG RADIATION, USING ADIABATIC  
TEMPERATURE  
A66-12447
- OUTPUT POWER AND PULSE DURATION OF RUBY LASER  
A66-12602
- PULSED LASER-CREATED PLASMAS BY LIGHT ABSORPTION  
BY SKIN EFFECT  
A66-12975
- INTENSE LASER BEAM FOCUSING EFFECT IN GAS TO  
STUDY LIGHT-INDUCED DISCHARGES BY TIME-RESOLVED  
SPECTROSCOPY AND PHOTOGRAPHY  
A66-12978
- INTERNAL BUBBLE FORMATION AND CRACKING IN RODS OF  
Q-SWITCHED RUBY AND ND-GLASS LASERS CAUSED BY  
LASER LIGHT, AND IN CASE OF ND-GLASS RODS, BY  
PLATINUM INCLUSIONS IN GLASS  
A66-13002
- PRESSURE DEPENDENCE OF DOMINANT EMISSION MODES  
FROM Pb Se DIODE LASER  
A66-13003
- POLARIZATION OF LIGHT FROM GLASS LASER DOPED WITH  
TWO PERCENT POSITIVE TRIVALENT NEODYMIUM MEASURED  
WITH TIME RESOLUTION OF LESS THAN MICROSECOND  
A66-13006
- INTENSITY DISTRIBUTION IN FABRY-PEROT  
INTERFEROMETER PRODUCING RESONANT WAVES FOR LARGE  
FRESNEL NUMBER APPLIED IN MODEL FOR FILAMENT-FORM  
LASER MECHANISM  
A66-13097
- MODEL FOR BEHAVIOR OF OPTICAL MASER IN STATIC  
MAGNETIC FIELD OF ARBITRARY STRENGTH IN Z  
DIRECTION AND IN ELECTROMAGNETIC FIELD COMPOSED OF  
TRAVELING WAVES  
A66-13135
- PULSE ENERGY AND POWER OF LASERS UNDER CONTINUOUS  
OPERATING CONDITIONS MEASURED, USING CALORIMETERS,  
PHOTOELECTRIC EFFECT OF RADIATION, ETC  
A66-13205
- LASERS AS TRIGGERING MECHANISM FOR SPARK GAPS,  
NOTING DELAY TIME BETWEEN PULSE ARRIVAL AND

## SUBJECT INDEX

## LASER OUTPUT CONT

- CURRENT FLOW A66-13247
- QUANTUM STATISTICS FOR ANALYZING RADIATION FIELDS INTERACTING WITH OTHER SYSTEMS APPLIED TO MODEL LASER OPERATING AS LINEAR AMPLIFIER A66-13260
- PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER A66-13307
- FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK SHOCK WAVE IN LASER BEAM A66-13308
- ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION INVERSION IN LEVELS OF OPTICAL TRANSITION A66-13311
- LASER WITH DIFFRACTION LIMITED RADIATION PATTERN A66-13313
- MEASURING DEVICE FOR PULSED LASER OUTPUT POWER USING BOLOMETER, AMPLIFIER AND OSCILLOSCOPE A66-13888
- EXPERIMENTS ON HELIUM-NEON FM LASERS COVERING PHASE-LOCKED AND FM REGION POWER OUTPUT, MODULATION INDEX AND DISTORTION EXPERIMENTS A66-13955
- CONSTRUCTION PROBLEMS OF CONTINUOUS-DUTY DC EXCITED ION LASERS A66-13956
- LASER OSCILLATIONS AND SELF Q-SWITCHING, DISCUSSING PULSED FLASH-LAMP EXCITATION EXPERIMENTS WITH TRIPLY ACTIVATED CONFOCAL BARIUM CROWN GLASS ETALON A66-13980
- HIGH POWER BREWSTER WINDOW LASER WITH GAS FILLS, DISCUSSING POWER OUTPUT AND EFFICIENCY PARAMETERS A66-13983
- STATIC CHARACTERISTICS OF GAS LASER INTERNAL MODULATION CIRCUIT, USING ELECTRO-OPTICAL CRYSTAL INSERTED INTO GAS LASER RESONATOR A66-14059
- FRACTURES IN NEODYMIUM-DOPED ALKALINE SILICATES AND BOROSILICATES PRODUCED BY LASER BEAM A66-14174
- CONICAL EMISSION IN RUBY LASERS WITH EXTERIOR MIRRORS A66-14278
- SPIKEFREE EMISSION FROM LASER USING LONG RUBY CRYSTAL DOPED HEAVILY WITH CHROMIUM AND SUITABLE SYMMETRY FOR PUMP RADIATION A66-14331
- RISE TIME AND OUTPUT POWER OF SINGLE PULSE IN HE-NE LASER MEASURED BY METHOD OF CHANGING Q-FACTOR BY PLATE LOCATED IN RESONANT CAVITY A66-14332
- INTERACTION OF LIGHT PULSE FROM RUBY LASER WITH MERCURY SURFACE, OBSERVING MECHANICAL IMPACT BELIEVED TO BE RAPID VAPORIZATION PROCESS A66-14373
- LASER BEAM USE IN BIOLOGY AND MEDICINE, NOTING INTERACTION OF ELECTROMAGNETIC RADIATION WITH BIOLOGICAL SYSTEMS, HAZARDS, DIAGNOSTICS, THERAPEUTICS, ETC A66-14455
- PLASMA GENERATION BY FOCUSING LASER BEAM IN AIR AT ATMOSPHERIC PRESSURE AND ROOM TEMPERATURE INDICATE CONNECTION WITH LUMINOUS ENERGY ABSORPTION DURING BREAKDOWN A66-14538
- MINORITY CARRIER LIFETIME IN SILICON MEASURED BY CONTACTLESS METHOD, USING LASER INDUCED MODULATION OF IR TRANSMISSION IN SILICON / LIMIRIS/ EFFECT A66-14563
- GALLIUM ARSENIDE P-N JUNCTION LASER DIODE COVERING INJECTION CURRENT DISTRIBUTION, DENSITY AND EMISSION SPECTRA VARIATION A66-14659
- THOMSON SCATTERING MEASUREMENTS OF MAGNETIC
- ANNULAR SHOCK TUBE PLASMAS USING Q-SWITCHED RUBY LASER LIGHT BEAM A66-14707
- RISE OF JUNCTION TEMPERATURE DURING CONTINUOUS OPERATION OF GA AS INJECTION LASER A66-14771
- ATMOSPHERIC BREAKDOWN LIMITATIONS TO OPTICAL MASER PROPAGATION A66-14837
- HELIUM-NEON LASER OUTPUT CHARACTERISTICS AS FUNCTION OF LASER PARAMETERS A66-14897
- LASER OSCILLATION IN CALCIUM TUNGSTATE CRYSTALS ACTIVATED WITH TRIVALENT PRASEODYMIUM A66-14898
- STIMULATED RAMAN AND BRILLOUIN SCATTERING FOR STOKES RADIATION PARALLEL TO LASER BEAM IN RECTANGULAR WAVEGUIDE A66-14901
- OUTPUT SPECTRA OF ARGON ION LASER IN RING RESONATOR AND TWO MIRROR RESONATORS A66-14904
- RUBY LASERS DISCUSSING OUTPUT CHARACTERISTICS, BEAM DIVERGENCE, BEAT MODES AND RESPECTIVE EXPERIMENTAL TECHNIQUES A66-14919
- PHOTOGRAPHIC FILM USED FOR QUANTITATIVE MEASUREMENTS OF INTENSITY DISTRIBUTION IN Q-SWITCHED LASER BEAM A66-14920
- ELECTRODELESS EXCITATION OF DISCHARGE IN HELIUM-NEON GAS LASER TUBE APPLIED TO VOICE TRANSMISSION A66-14924
- FRAUNHOFER PATTERN OF LASER LIGHT TRANSMITTED THROUGH OPTICAL FIBER, NOTING SPATIAL FREQUENCY OF INTERFERENCE FRINGES BETWEEN LIGHT WAVES A66-14972
- LASER OSCILLATIONS OF SILICON TETRACHLORIDE, SILICON TETRAFLUORIDE AND ETHYL SILICATE IN GASEOUS DISCHARGE A66-14973
- TIME DEPENDENT EMISSION BEHAVIOR OF RUBY LASER DISCUSSING RATE EQUATIONS, Q-VALUE, OUTPUT POWER, STEADY STATE VALUES, ETC A66-14981
- EVOLUTION OF LUMINOUS ZONE OF PLASMA GENERATED BY FOCUSING LASER BEAM IN AIR A66-15097
- AIRBORNE LASER-RADAR LIGHT DETECTION AND RANGING / LIDAR/ SYSTEMS APPLIED TO DETECTION OF CLEAR AIR TURBULENCE / CAT/ A66-15297
- PROPAGATION RATE OF HIGH POWER LASER LIGHT PULSE IN INVERSELY POPULATED MEDIUM A66-15333
- OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-15352
- MODULATION OF LASER LIGHT WITH COMPOSITE FABRY-PEROT RESONATOR, USING MORE THAN THREE MULTIPLE REFLECTING PLATES A66-15836
- INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY AFTER LEAVING LASER AND AFTER FOCUSING WITHIN LENS, NOTING OPTIMUM FOCUSING CONDITIONS A66-15853
- OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF SOLID STATE LASER AND COMPENSATION VIA LENS IN RESONATOR A66-15854
- ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION DURING OPTICAL PUMPING, NOTING RELATION BETWEEN ENERGY ABSORPTION AND POPULATION INVERSION A66-15858
- POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR A66-15861
- VARIATION OF SCATTERING CROSS SECTION WITH BEAM INTENSITY FOR RUBY LASER LIGHT ON ATOMIC HYDROGEN



- A66-15864  
DISPERSION RESONATOR PERFORMANCE IN RUBY LASER,  
SHOWING GENERATION OF R SUB 1 AND R SUB 2 LINES  
A66-16346
- C W LASER ACTION IN CARBON DIOXIDE-HELIUM MIXTURES  
A66-16385
- RUBY LASER NOISE RADIATION CONSISTING OF INCREASED  
LUMINESCENCE AND Laterally DISPERSED GENERATION  
DETERMINED FROM ENERGY LEVEL POPULATIONS  
A66-16628
- OPTICAL DESIGN OF ELLIPTICAL CAVITIES AND  
COMPARISON OF ENERGY TRANSFERS FROM LIGHT SOURCE  
TO RUBY LASER WITH CYLINDRICAL CAVITIES  
A66-16647
- LASER COMMUNICATIONS LINK SECURITY AGAINST  
INTERCEPTION, EXAMINING FREQUENCY BANDWIDTH FOR  
MINIMUM SNR  
A66-16650
- HELIUM-NEON GAS LASERS, DISCUSSING AMPLITUDE  
VARIATION SUPPRESSION TECHNIQUE  
A66-16670
- REGULAR PERIODIC SPIKING IN OUTPUT OF PULSED  
NEODYMIUM DOPED BORATE GLASS LASER AT PUMPING  
LEVELS SLIGHTLY ABOVE THRESHOLD  
A66-16672
- LIFE PERFORMANCE CHARACTERISTICS OF UNCOATED RUBY  
LASER Q-SWITCHED BY ROTATING PRISM FORMING END  
REFLECTOR OF LASER RESONATOR  
A66-16675
- GROUND STATE ESR SATURATION EFFECT ON RUBY LASER  
OUTPUT FREQUENCY AT CRYOGENIC TEMPERATURE  
A66-16753
- C W HIGH-POWER CARBON DIOXIDE-NITROGEN-HELIUM  
LASER OPERATION, NOTING HELIUM ADDITION  
A66-16754
- STIMULATED EMISSION IN INDIUM ARSENIDE SHOWS  
EXCITATION THRESHOLD LOW AND LIGHT EMISSION HIGHLY  
DIRECTIONAL  
A66-17026
- GAS BREAKDOWN BY LASER CAN BE ACCOUNTED FOR BY  
BOTH MICROWAVE BREAKDOWN THEORY AND INVERSE  
BREMSSTRAHLUNG  
A66-17040
- IONIZATION UNDER LASER ACTION EXTENDED TO METALS  
AND DIELECTRICS, NOTING INFLUENCE ON THRESHOLDS  
A66-17065
- CONVENTIONAL FLOW VISUALIZATION USING LASER LIGHT  
SOURCE  
AIAA PAPER 66-127  
A66-17104
- LIGHT OUTPUT FROM HELIUM-NEON GAS MASER  
PHOTOGRAPHED WITH AND WITHOUT INTRACAVITY  
MODULATION AT LOCKING FREQUENCY, USING HIGH SPEED  
ROTATING MIRROR  
A66-17205
- COHERENT INTERFERENCE REJECTION, DISCUSSING NOISE  
AND MODULATOR-LEAKAGE PICKUP REJECTION IN LASER  
COMMUNICATIONS EXPERIMENTS  
A66-17217
- FUSED SILICA OUTPUT COUPLING COMPONENT FOR LASER  
SYSTEM, USING FRUSTRATED TOTAL INTERNAL REFLECTION  
CONFIGURATION  
A66-17287
- RECORDING SAMPLING SYSTEM FOR MEASURING ENERGY  
INCIDENT ON BIOLOGICAL SYSTEM EXPOSED TO LASER  
BEAM  
A66-17293
- LASER RADIATION ABSORBED ALONG SLANT PATHS,  
SPECTRAL LINE OVERLAPPING AND CENTER LINE SHIFT  
WITH PRESSURE VARIATION  
A66-17295
- TEMPERATURE DEPENDENCE OF EMISSION SPECTRUM AND  
THRESHOLD CURRENT IN GA AS LASERS  
A66-17333
- EXCITATION OF SEMICONDUCTOR LASERS BY BEAM OF FAST  
ELECTRONS, DISCUSSING WORK OF SHOCKLEY, POPOV,  
KELDYSH AND KROKHIN  
A66-17337
- LASER-BEAM SCATTERING BY INDIVIDUALLY INTRODUCED  
CHARGED POLYSTYRENE SPHERICAL PARTICLES AND  
DROPLETS OF NAPHTHALENE AND WATER IN COMBINATION  
A66-17473
- OSCILLATION SPIKES IN QUASI-CONTINUOUS OPERATION  
OF RUBY LASER AT ROOM TEMPERATURE, NOTING  
THRESHOLD PUMPING ENERGY  
A66-17532
- COMPTON SCATTERING OF LASER PHOTONS, NOTING  
TRANSFORMATION INTO GAMMA RADIATION PHOTONS UPON  
COLLISION WITH HIGH ENERGY ELECTRONS  
A66-17816
- ISOTOPE SHIFT, LINEWIDTH AND PRECISE WAVELENGTH OF  
LASER EMISSION IN IONIZED HG  
A66-18035
- PULSED LASER WELDING, WIRE-TO-WIRE, SHEET-TO-  
SHEET, CIRCUIT BOARD, VACUUM TUBE, ETC  
A66-18153
- DIFFRACTION VELOCIMETER DETECTING AND MEASURING  
TRANSVERSE MOVEMENT OF SURFACE BY SENSING LIGHT  
BACKSCATTERED BY IT WHEN LASER ILLUMINATED  
A66-18333
- ELECTRON ENERGY SPECTRA IN NEON, XENON AND HELIUM-  
NEON LASER DISCHARGES, CALCULATING PRODUCTION AND  
DESTRUCTION RATE PARAMETERS  
A66-18354
- STABLE SINGLE-FREQUENCY OUTPUT FROM LASER CAVITY  
OBTAINED BY FILTER METHOD AND RESONANCE  
SUPPRESSION METHOD  
A66-18356
- FREQUENCY STABILIZATION OF GAS LASERS, USING  
ATOMIC RESONANCE AND INTERFEROMETERS  
A66-18357
- TIME RESOLUTION OF ELECTRON AND ION EMISSION  
PRODUCED BY Q-SWITCHED RUBY LASER PULSE FOCUSED  
ON METAL SURFACE  
A66-18358
- OSCILLATION, MODULATION AND TRANSMISSION PROBLEMS  
REGARDING LONG DISTANCE ELECTRIC SIGNAL  
COMMUNICATION POSSIBILITIES OF LASERS  
A66-18359
- REPLICA TECHNIQUES AND ELECTRON AND OPTICAL  
MICROSCOPY TO STUDY LASER IRRADIATED METAL  
SURFACES  
A66-18393
- ORGANIC CATIONS EFFECT ON LASER THRESHOLD OF  
SOLUTIONS OF TETRAKIS FORM OF EUROPIUM  
BENZYLTRIFLUOROACETONATE  
A66-18418
- LASER ACTION ON ROTATIONAL TRANSITIONS OF 10-9, 9-  
8, 8-7, 7-6 AND 6-5 VIBRATIONAL BANDS OF GROUND  
ELECTRONIC STATE CO  
A66-18424
- INTENSITY FLUCTUATIONS IN OUTPUT OF FOUR-LEVEL  
CW LASER OSCILLATORS BY LINEARIZED RATE EQUATIONS  
A66-18434
- PEAK IRRADIANCE OF OPTICAL PUMP AND TOTAL  
PUMP-ENERGY INCIDENT UPON LASER CRYSTAL  
DETERMINED, ACCOUNTING FOR TEMPERATURE VARIATION  
EFFECTS  
A66-18487
- HELIUM-NEON GAS DISCHARGE INTENSIFICATION FOR  
6328 A LASER WAVELENGTH, DISCUSSING MEASUREMENT  
TECHNIQUES, GAIN PARAMETERS AND RESULTS  
A66-18632
- STATISTICAL MODEL OF RANDOM QUASI-SINUSOIDAL  
FUNCTION OF CONSTANT AMPLITUDE REPRESENTED BY  
EMISSION OF LASER OR RADIO TRANSMITTER  
A66-18637
- LASER DEVELOPMENT, DISCUSSING BASIC THEORY,  
PUMPING METHODS AND LASER TYPES  
A66-18700
- CROSS SECTION MEASUREMENT FOR ELECTROMAGNETIC  
BACKSCATTERING OF LASER BEAMS FROM ROUGH ALUMINUM  
AND MAGNESIUM OXIDE SURFACES  
A66-18930
- LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION  
A66-18970

HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A66-18972

HIGHER ORDER CALCULATION OF LASER OUTPUT, NOTING  
APPROXIMATION METHOD FOR LINewidth PARAMETER AND  
LAMB DIP SHAPE ACCURACY A66-19063

CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY  
SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY  
LASER A66-19269

GAS LASER EMISSION SOLUTION BY DETERMINING  
EMISSION FIELD DENSITY DEPENDENCE ON RESONATOR  
PARAMETERS, RELAXATION CHARACTERISTICS AND ATOM  
EXCITATION IN GAS DISCHARGE PLASMA A66-19271

LASER REGIME WITH GIANT PULSES GENERATED IN  
DYSPROSIUM DOPED CADMIUM FLUORIDE UNDER CONTINUOUS  
PUMPING BY XENON LAMPS, OBTAINING Q FACTOR  
MODULATION BY ROTATING PRISM A66-19376

THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-19669

MICROMACHINING WITH PULSED HELIUM-NEON GAS LASER,  
NOTING EXPERIMENTAL TECHNIQUES, OPERATION AND  
APPLICATION A66-19734

WAVELENGTH CHANGE OF SPONTANEOUS AND STIMULATED  
EMISSION WITH UNIAXIAL PRESSURE UNDER CW  
OPERATION OF GA AS DIODE LASER AT 4 DEGREES K  
A66-19922

DATA PULSED TRANSMISSION OVER ELECTRON-INJECTION  
LASER COMMUNICATION SYSTEM, USING CONTINUOUS WAVES  
A66-19934

OPTICALLY BIASED PULSED TRANSMISSION MODE  
OPERATION OF Q-SWITCHED LASER, IN CONNECTION WITH  
KERR CELLS INHIBITING LASING ACTION A66-19937

SHARPLY DIRECTIONAL COHERENT RADIATION GENERATION  
BY SYNCHRONIZED LASERS OR MULTIMIRRORRED RESONATOR  
OF SINGLE LASER A66-19945

SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER  
RADIATION, DETERMINING TEMPERATURE OF PLASMA  
PRODUCED NEAR FOCUS A66-19959

INDUCED RADIATION AT HIGH PHOTON DENSITIES, NOTING  
APPLICABILITY OF PERTURBATION THEORY TO  
MULTIPHOTON RESONANCE RADIATION OF LASERS  
A66-20344

OUTPUT POWER OF CW LASER MEASURED BY WIRE  
BOLOMETER IN FORM OF PLANE SINGLE-LAYER SPIRAL AS  
SENSITIVE ELEMENT A66-20364

EFFECT OF LOAD MISMATCH ON LASER OUTPUT,  
DETERMINING NONLINEAR DEPENDENCE OF EQUIVALENT  
NEGATIVE CONDUCTANCE AS FUNCTION OF OSCILLATION  
AMPLITUDE IN LASER RESONATOR CAVITY A66-20435

INTENSE UV PUMPING EFFECT ON RUBY LASER OUTPUT  
A66-20519

SOLID STATE LASER OUTPUT EXHIBITING REGULAR AND  
IRREGULAR SPIKES ANALYZED THROUGH RELAXATION  
OSCILLATIONS AND CLASSICAL PHYSICS A66-20568

SUPERCONDUCTORS APPLIED TO MAGNETS, LASERS AND  
MHD POWER GENERATION A66-20674

OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING  
POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED  
POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-20893

LASER RADAR AS INSTRUMENT TO OBTAIN OPERATIONAL  
METEOROLOGICAL INFORMATION A66-21067

ISOTOPE SHIFT MEASUREMENT FOR 6328 ANGSTROMS  
HELIUM-NEON LASER TRANSITION A66-21070

LASER CONFIGURATION GENERATING SINGLE FREQUENCY  
RADIATION IN SINGLE SPATIAL MODE WITH HIGH OUTPUT  
ACHIEVED BY SUPPRESSING ALL RESONANCES BUT ONE  
A66-21250

DIELECTRIC CAVITY MASER COMPOSED OF RUBY ROD  
SEPARATING METAL PLATES, NOTING STRENGTH  
SATURATION BEHAVIOR, POWER OUTPUT, ETC A66-21308

PUMP POWER DEPENDENCE OF RUBY LASER STARTING AND  
STOPPING TIME PREDICTED VIA RATE EQUATION ANALYSIS  
A66-21309

SPIKING BEHAVIOR OF MULTIMODE RUBY LASER IN  
SPHERICAL RESONATOR, INTERPRETING NEAR-FIELD  
PATTERNS, FREQUENCY SPECTRUM, ETC A66-21311

LASER INDUCED GAS BREAKDOWN AT HIGH PRESSURES,  
NOTING EFFECT OF PLASMA DENSITY ON INDEX OF  
REFRACTION VIA OPTICAL FREQUENCY RESONANCE  
MEASUREMENT A66-21564

CW LASER ACTION ON TRIPLE STATE PHOSPHORUS-SULFUR  
TRANSITION, USING HYDROGEN SULFIDE-NOBLE GAS  
MIXTURES A66-21577

EFFECTIVE MASS IN IN AS AND IN SB FROM LANDAU  
SHIFT OF PEAK EMISSION IN LASER DIODES A66-21579

CARNAHAN PROPOSED FIRST ORDER ETHER DRIFT  
EXPERIMENT USING TWO LASERS SHOWN TO BE OF SECOND  
ORDER NATURE, NOTING ROLE OF PHASE SHIFTS  
A66-21656

IONIZATION PHENOMENA IN ARGON DUE TO LASER  
RADIATION BY MEASURING ELECTRON DENSITY AND ENERGY  
AS TIME FUNCTION AFTER LASER PULSE INITIATION AT  
DIFFERENT GAS PRESSURES AND PREIONIZED CONDITIONS  
AIAA PAPER 66-176 A66-21690

THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-21836

SILICON AND SELENIUM DOPING EFFECTS ON GALLIUM  
ARSENIDE LASER CHARACTERISTICS A66-21879

SOVIET AND FOREIGN PAPERS ON PLASMA DIAGNOSTICS BY  
SCATTERING OF LASER BEAMS AT PLASMA ELECTRONS  
A66-21990

SECOND HARMONIC GENERATION BY LASER BEAMS OF  
FINITE SPECTRAL WIDTH, USING QUANTUM TRANSITIONS  
AND KINETIC EQUATIONS, NOTING SHAPE OF PUMPING  
LINE AT FUNDAMENTAL FREQUENCY A66-22026

DEGREE OF EXCITATION OF METASTABLE STATE  
DETERMINED, USING LUMINESCENCE SATURATION  
PHENOMENON, CALCULATING POPULATION OF WORKING  
LEVEL OF LASER SUBSTANCE A66-22027

MEASUREMENT OF RADIATION PATTERN OF RUBY LASER  
EMISSION FOR VARIOUS RESONATORS AND OPERATING  
REGIMES, NOTING LASER EFFECT ON ANGULAR HALF-WIDTH  
VALUES A66-22028

HIGH SENSITIVITY FAST-RESPONSE LASER DETECTION  
SYSTEM, DESCRIBING MICROWAVE RESPONSE  
PHOTOELECTRIC DETECTOR WITH AMPLIFICATION AND  
MIXING FUNCTIONS A66-22046

GALLIUM ARSENIDE LASER EXCITATION BY FAST  
ELECTRONS A66-22146

PLASMA PRODUCTION BY OPTICAL IRRADIATION OF GASES  
AND BY SOLIDS, CONSIDERING INTERACTION OF LASER  
RADIATION WITH SURFACES AND IRRADIATION OF  
PARTICLES OF SOLID MATERIAL IN VACUUM  
AIAA PAPER 66-174 A66-22212

DISPERSION RESONATOR PERFORMANCE IN RUBY LASER,  
SHOWING GENERATION OF R SUB 1 AND R SUB 2 LINES  
A66-22345

EQUATIONS OBTAINED FROM HAMILTONIAN FOR COUPLING,  
FIRST STOKES LINE, FIRST ANTI-STOKES LINE AND

## COHERENT FIELD FOR RAMAN LASER

A66-22490

WAVELENGTH MEASUREMENT OF HELIUM-NEON LASER  
EMISSION BY DOUBLE-CHANNEL RECORDING  
INTERFEROMETER, USING KRYPTON-86 PRIMARY STANDARD  
A66-22874

OPTICAL DIFFRACTION VELOCIMETER, USING  
BACKSCATTERED LASER LIGHT TO MEASURE RELATIVE  
VELOCITY BETWEEN LIGHT SOURCE AND SURFACE  
A66-22958

MOON SHAPE DETERMINED BY MEASURING DISTANCE FROM  
LUNAR SURFACE POINTS TO LUNAR CENTER OF MASS,  
USING OPTICAL LASER RADAR  
A66-22964

DESIGN AND OPERATION OF HELIUM-NEON LASER NOTING  
RADIATION, FREQUENCY STRUCTURE, POWER DENSITY,  
EXTERNAL MAGNETIC FIELD EFFECT, APPLICATION, ETC  
A66-22980

HE- NE LASER IR RADIATION EMISSION ATTENUATED BY  
ATMOSPHERIC METHANE  
A66-23090

CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER  
A66-23309

MACH- ZEHNDER LASER INTERFEROMETER AS DIAGNOSTIC  
TOOL IN SHOCK TUBE EXPERIMENTS  
A66-23352

CARBON AND ETHYLENE TETRACHLORIDE ULTRASONIC  
MODULATORS APPLIED TO IR LASER HETERODYNE  
EXPERIMENTS ON IN AS PHOTODIODE  
A66-23353

LASER ACTION ON ROTATIONAL LINE IN CARBON DIOXIDE  
AND NITROUS OXIDE VIBRATIONAL SPECTRA IN BOTH P  
AND R BRANCHES UP TO J VALUES OF OVER 50  
A66-23357

EFFICIENT CONVERSION OF ELECTRICAL ENERGY INTO  
LASER RADIATION, USING COAXIAL OPTICAL PUMP  
A66-23479

SINGLE PULSE OPERATION OF LASERS, NOTING ENERGY  
STORAGE AND AMPLIFICATION EFFECT FOR FOUR- AND  
THREE-LEVEL ACTIVE MEDIUM  
A66-23667

LASER RANGING VIA DIGITAL COUNTER COUPLED  
PHOTOMULTIPLIER TUBE, NOTING SPECTRAL RESPONSE,  
GAIN TRANSIT TIME DEPENDENCE, OUTPUT COUPLING AND  
EFFECTIVE CATHODE DIAMETER  
A66-23759

SPATIAL AMPLITUDE OF FIELD OF IDEALLY PARALLEL  
LASER BEAM FOCUSED BY OPTICAL SYSTEMS WITH  
SPHERICAL ABERRATION  
A66-23778

LASER APPLICATION AND TECHNIQUES NOTING  
AMPLIFICATION, MODULATION, INTERFEROMETRY,  
SCATTERING, PLASMA DIAGNOSTICS, NONLINEAR OPTICS,  
ETC  
A66-23931

POLISH-MADE HE- NE RED GAS LASERS, DESCRIBING  
POWER OUTPUTS, GAS PRESSURE, HE/ NE RATIO,  
MIRROR TRANSMISSION COEFFICIENT AND  
INTERFEROMETRIC APPLICATION  
A66-23946

CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION  
A66-24009

OPTICALLY PUMPED RUBIDIUM 87 MASER OSCILLATOR  
A66-24124

FOCUSED ENERGY TECHNIQUES FOR JOINING, INCLUDING  
LASER WELDING  
ASTME PREPRINT AD66-718  
A66-24413

LASER WELDING FOR PRODUCTION MICROWELDING, NOTING  
DESIGN, CONSTRUCTION AND APPLICATION  
ASTME PREPRINT MM66-707  
A66-24415

SPATIALLY INDEPENDENT LASER RATE EQUATION  
GENERALIZED FOR MULTIMODE EFFECTS, NOTING STEADY  
STATE OSCILLATION THRESHOLD SINGULARITIES, SPIKING  
PARAMETERS, ETC  
A66-24560

STEADY STATE VALUE OF INVERTED POPULATION, POWER

OUTPUT, THRESHOLD BEHAVIOR AND SPIKING  
CHARACTERISTICS FOR SINGLE-MODE LASER WHEN  
RADIATION INTENSITY HAS SPATIAL DEPENDENCE  
A66-24562

PULSED INDUCED EMISSION IN HYDROGEN BEAM LASER FOR  
CASE OF TWO RELAXATION TIMES, DETERMINING  
POLARIZATION ONLY BY NUMBER OF ACTIVE PARTICLES IN  
RESONATOR  
A66-24884

DEPENDENCE OF EMISSION INTENSITY OF GAS LASER ON  
LONGITUDINAL AND TRANSVERSE MAGNETIC FIELDS, USING  
SIMPLIFIED MODEL  
A66-24885

TREATMENT OF STEEL WITH LASER BEAM, OBTAINING  
PRECISION HOLES WITHOUT AFFECTING MICROHARDNESS OF  
METAL  
A66-24898

CORRELATION FUNCTIONS OF AMPLITUDE AND INTENSITY  
FLUCTUATION FOR LASER MODEL NEAR THRESHOLD  
OBTAINED BY USING DISTRIBUTION FUNCTIONS EVALUATED  
BY FOKKER- PLANCK EQUATION, TREATING AMPLITUDE AS  
RANDOM VARIABLE  
A66-25018

MODULATING OUTPUT OF SOLID-STATE LASERS  
C-920259-12  
N66-12814

EMISSION SPECTROSCOPY AND COORDINATION CHEMISTRY  
OF EUROPIUM CHELATE SOLUTIONS - CHELATE LASERS  
INVESTIGATED FOR EVALUATING POTENTIALITIES OF  
LIQUID LASERS  
TR-65-052-11  
N66-14177

FORMATION TIME OF OPTICAL LASER OSCILLATIONS  
N66-15050

RESEARCH IN CHINESE PEOPLES REPUBLIC - SOLAR  
FLUX, GAS DISCHARGE TUBE, NEODYMIUM LASER,  
GEOLOGICAL MECHANICS, MICROCRYSTALLINE GLASS,  
LOCATING OF THUNDER, AND PURIFICATION WITH  
DISTILLATION METHODS  
JPRS-33759  
N66-16806

TRANSMISSION CHARACTERISTICS OF NEODYMIUM LASER  
N66-16812

SENSING OF METEOROLOGICAL VARIABLES BY LASER  
PROBE TECHNIQUES  
NASA-CR-71397  
N66-21657

## LATTICE

PEROVSKITE LASER HOST MATERIALS HAVING CUBIC  
CENTROSYMMETRIC CRYSTAL LATTICE SITES  
UACRL-D910269-5  
N65-35429

CRYSTAL GROWTH, LATTICE CONSTANT, AND DENSITY OF  
MAGNESIUM POTASSIUM FLUORIDE AND BARIUM  
ZIRCONATE  
AD-623511  
N66-14467

## LEAD SELENIDE

PB SE DIODE LASER FABRICATION, PROPERTIES AND  
EMISSION SPECTRUM WITH PEAK AT 8.5 MICRONS  
A65-27602

LASER ACTION AT LIQUID HELIUM TEMPERATURE IN  
CRYSTALS OF LEAD SAMARIUM, LEAD SELENIDE AND LEAD  
TELLURIDE EXCITED BY FAST ELECTRON BEAM  
A65-30346

PRESSURE DEPENDENCE OF DOMINANT EMISSION MODES  
FROM PB SE DIODE LASER  
A66-13003

## LEAD TELLURIDE

LASER ACTION AT LIQUID HELIUM TEMPERATURE IN  
CRYSTALS OF LEAD SAMARIUM, LEAD SELENIDE AND LEAD  
TELLURIDE EXCITED BY FAST ELECTRON BEAM  
A65-30346

## LENS

FLARE IMAGES ROLE IN SELF-DESTRUCTION OF LENS IN  
STRONG LASER BEAM  
A65-32228

## LENS DESIGN

LOSSLESS CONVERSION OF PLANE LASER WAVE TO PLANE  
WAVE OF UNIFORM IRRADIANCE, NOTING PLANOASPHERIC  
LENSES METHOD AND ABERRATED LENS SYSTEM  
A66-12204

## SUBJECT INDEX

## LIGHT COMMUNICATION DEVICE

- TWO LENSES WITH FOCAL RATIOS OF F/4 AND F/2.65  
USED TO COLLIMATE LIGHT FROM HELIUM-NEON LASER  
A66-14921
- IRREGULAR BENDS AND LENS DISPLACEMENTS EFFECT ON  
WAVELENGTH AND MODES IN LASER WAVEGUIDE  
A66-23103
- LIDAR**  
LASER RANGING EXPERIMENTS PERFORMED WITH BEACON  
EXPLORER B  
A65-21303
- LIGHT DETECTION AND RANGING / LIDAR/ TECHNIQUE USE  
IN ATMOSPHERIC RESEARCH, PARTICULARLY  
METEOROLOGICAL FACTORS IMPORTANT TO AVIATION AND  
ROCKET OPERATIONS  
AIAA PAPER 65-464  
A65-30204
- AIRBORNE LASER-RADAR LIGHT DETECTION AND RANGING  
/ LIDAR/ SYSTEMS APPLIED TO DETECTION OF CLEAR AIR  
TURBULENCE / CAT/  
A66-15297
- LASER RADAR AS INSTRUMENT TO OBTAIN OPERATIONAL  
METEOROLOGICAL INFORMATION  
A66-21067
- LIFE SCIENCE**  
DATA ON LASER MATERIALS REFERENCED TO MAY 1964  
INCLUDING LASER EMISSION LINES AND LASER  
PERFORMANCE PARAMETERS  
A65-22616
- LIFE SUPPORT SYSTEM**  
LIFE SUPPORT SYSTEM, FLUID AMPLIFICATION,  
SPALLING, COMMUNICATIONS SATELLITE, MICROWAVE  
APPARATUS, HIGH STRENGTH STEEL, TRACERS, LASERS,  
ATMOSPHERIC TURBULENCE, AND RESONANCE  
AD-611432  
N65-22732
- GIANT RADIO TELESCOPE TO DETECT EXTRATERRESTRIAL  
RADIATION, RAMAN SCATTERING LASERS, FORECASTING  
SOLAR FLARES FOR MANNED SPACE FLIGHT, VOSKHOD  
II LIFE SUPPORT, AND ALUMINUM NITRIDE FILMS  
N65-32675
- LIGHT**  
LASER BEAM DEFLECTION MODULATION OBTAINED BY  
PASSING CURRENT THROUGH CADMIUM SULFIDE PRISM WITH  
OHMIC CONTACTS, USED FOR THERMOCOUPLE MEASUREMENTS  
A66-25890
- EFFICIENT DIFFRACTION OF INCIDENT LASER BEAM AT  
BRAGG ANGLE INCIDENCE INTO FIRST-ORDER MODE,  
USING TRAVELING ULTRASONIC WAVES IN WATER  
A65-33057
- COMPARISON OF UNDERWATER ATTENUATION OF RUBY  
LASER LIGHT WITH NONLASER LIGHT  
NRL-6181  
N65-28158
- DYNAMICS AND CHARACTERISTICS OF SELF-TRAPPING OF  
INTENSE LIGHT BEAMS  
NASA-CR-74030  
N66-23765
- LIGHT, SPEED OF**  
COHERENT LASER BEAM USED TO SHOW CONSTANCY OF  
VELOCITY OF ELECTROMAGNETIC RADIATION  
A65-14215
- LIGHT ABSORPTION**  
LASER POWER DENSITY MEASURED WITH REDUCED  
ABSORPTION OF LIGHT BY METHYLENE BLUE, USING HE-  
NE- CW LASER  
A65-31455
- DISPERSION OF 1.15 MICRON HE- NE LASER LINE  
RESULTING FROM NEON ABSORPTION TRANSITION  
A65-31762
- THERMAL DISTORTION, EXPANSION AND SCATTERING IN  
RUBY AND GLASS LASER RODS DURING AND AFTER PUMP  
FLASH  
A65-35068
- NANOSECOND HEATING OF AQUEOUS SYSTEMS BY GIANT  
LASER PULSES AND REDUCTION OF LIGHT ABSORPTION  
AT HIGH LASER POWER DENSITIES  
AD-451466  
N65-16471
- PULSED LASER-CREATED PLASMAS BY LIGHT ABSORPTION  
BY SKIN EFFECT  
A66-12975
- LASER DIGITAL DEVICES, EXAMINING QUENCHING OF GAIN  
AND OPTICAL ABSORPTION  
A66-14826
- LIGHT AMPLIFIER**  
STATIONARY AND TRANSIENT LIGHT AMPLIFICATION  
REGIMES IN ACTIVE MEDIA OPERATING ACCORDING TO  
FOUR-LEVEL SCHEME  
A65-18455
- PHENOMENOLOGICAL TREATMENT OF SATURATION EFFECTS  
IN SOLID STATE LASER AMPLIFIERS  
A65-18887
- GAIN NARROWING OF INHOMOGENEOUSLY BROADENED LINE  
IN STIMULATED EMISSION IN LASER AMPLIFIER  
A65-22615
- STATIONARY AND TRANSIENT LIGHT AMPLIFICATION  
REGIMES IN ACTIVE MEDIA OPERATING ACCORDING TO  
FOUR-LEVEL SCHEME  
A65-28084
- FABRY- PEROT MULTILAYER LASER AMPLIFIER SOLUTIONS  
FROM TRANSIENT THEORY POINT OF VIEW, USING  
LAPLACE TRANSFORM  
A65-29926
- LASER BIBLIOGRAPHY / JUNE TO DECEMBER 1964/  
A65-32749
- LASER BEAM AMPLIFICATION BY REFLECTION FROM  
SCANNING GAS LASER ACTIVE INTERFEROMETER  
A65-33047
- INTERACTION BETWEEN OPTICAL MASER MEDIUM AND  
ELECTROMAGNETIC PULSE PROPAGATING IN IT,  
DISCUSSING AMPLIFIER EQUATIONS AND STEADY STATE  
PULSE / SSP/ IN AND OUT OF RESONANCE  
A65-33374
- WAVEGUIDE COUPLING BETWEEN ADJACENT PARALLEL  
FIBERS AS MEANS OF TRANSFERRING RADIATION FROM  
ONE ELEMENT TO ANOTHER  
A66-14827
- SPONTANEOUS EMISSION NOISE PROPERTIES OF PAIR OF  
PULSED RUBY LASER AMPLIFIERS  
A66-21310
- NONLINEAR AMPLIFICATION OF LIGHT PULSE PASSING  
THROUGH LASER OPERATING AT SATURATION REGIME  
A66-21963
- DISPERSION EFFECTS IN LASER AMPLIFIERS  
AFOSR-65-2211  
N66-16411
- LIGHT COMMUNICATION DEVICE**  
TRAVELING-WAVE TUBE WITH PHOTOELECTRIC CATHODE  
USED AS DEMODULATOR FOR LASER COMMUNICATION  
A65-14345
- OPTICAL COHERENT WAVE PROPERTIES SUITABLE FOR LONG  
DISTANCE LASER COMMUNICATIONS AND COMPARED WITH  
RADIO WAVE CHARACTERISTICS  
A65-2C006
- OPTICAL COMMUNICATION IN SPACE USING LASERS,  
EMPHASIZING NATURAL LIMITATIONS, E.G., ATMOSPHERIC  
ABSORPTION  
A65-21077
- IMPROVEMENTS NEEDED IN LASER TECHNOLOGY BEFORE  
OPTICAL COMMUNICATION CAN REPLACE UHF BECAUSE OF  
LIMITED RELIABILITY OF MICROBEAM OPTICAL LINK  
A65-23196
- SYSTEMS ANALYSIS OF LASERS VS MICROWAVES FOR  
MARS-TO- EARTH COMMUNICATIONS IN 1970  
A65-28248
- ACQUISITION AND REACQUISITION IN SPACECRAFT-  
SPACECRAFT AND SPACECRAFT-TO- EARTH COMMUNICATIONS  
USING LASER SYSTEMS  
A65-28249
- SPACE COMMUNICATION REQUIREMENTS USING LASERS AND  
MICROWAVES IN MANNED MARS FLIGHTS  
AIAA PAPER 65-324  
A65-3C519
- LASER APPLICATION IN MEDICINE, MANUFACTURING,  
SPECTROSCOPY, OPTICS AND COMMUNICATIONS  
A65-31882
- ATMOSPHERIC TURBULENCE EFFECT ON OPERATION OF  
DUAL-POLARIZATION FM LASER COMMUNICATION SYSTEM  
A65-33377
- ACQUISITION, TRACKING AND BEAM POINTING FOR

- OPTICAL COMMUNICATION IN SPACE  
AIAA PAPER 64-420 A65-33536
- ECONOMICAL FEASIBILITY REQUIREMENTS FOR OPTICAL  
MASER COMMUNICATIONS SYSTEMS A66-11301
- LASER BEAM MODULATION METHODS ASSESSED FOR MAKING  
USE OF CAPABILITY OF LASER FOR CARRYING MULTITUDE  
OF SIGNALS SIMULTANEOUSLY A66-11692
- ELECTRODELESS EXCITATION OF DISCHARGE IN HELIUM-  
NEON GAS LASER TUBE APPLIED TO VOICE TRANSMISSION  
A66-14924
- LASER COMMUNICATIONS LINK SECURITY AGAINST  
INTERCEPTION, EXAMINING FREQUENCY BANDWIDTH FOR  
MINIMUM SNR A66-16650
- SEARCH VIA LASER RECEIVERS FOR INTERSTELLAR  
COMMUNICATIONS A66-16669
- COHERENT INTERFERENCE REJECTION, DISCUSSING NOISE  
AND MODULATOR-LEAKAGE PICKUP REJECTION IN LASER  
COMMUNICATIONS EXPERIMENTS A66-17217
- OSCILLATION, MODULATION AND TRANSMISSION PROBLEMS  
REGARDING LONG DISTANCE ELECTRIC SIGNAL  
COMMUNICATION POSSIBILITIES OF LASERS A66-18359
- PARAMETER DEPENDENCE OF INTERMEDIATE FREQUENCY  
VOLTAGE INDICATED DURING ESTABLISHMENT OF OPTIMUM  
CONDITIONS FOR OPTICAL RECEIVERS AND MERIT OF  
SUBCARRIER MIXING A66-23960
- GALLIUM ARSENIDE LASER DIODES WITH HIGH OUTPUT  
COHERENT BEAM FOR COMMUNICATIONS SYSTEMS  
ECOM-2629 N66-21293
- COHERENT LIGHT COMMUNICATION SYSTEM FOR ATMOSPHERE  
CONDITION EFFECTS ON FREQUENCY MODULATED LASER  
BEAM  
FR-66-14-37 N66-21774
- LIGHT ELEMENT**  
ABSORPTION COEFFICIENT OF RUBY LASER RADIATION  
IN FULLY IONIZED LIGHT ELEMENTS  
IPP-6/27 N65-30178
- LIGHT EMISSION**  
HYPERSONIC WAVES PRODUCED BY BRILLOUIN EFFECT,  
USING METHOD OF TWO INTENSE LIGHT BEAMS  
A65-14874
- LASER OSCILLATION WHEREIN LASER MODES OSCILLATE  
WITH APPROXIMATELY FM PHASES THEREBY COMPRISING  
SIDEBANDS OF FM LIGHT SIGNAL A65-21876
- PHYSICAL CONDITIONS FOR OBTAINING LASER EFFECT IN  
P-N JUNCTION AND TECHNOLOGY IN CONSTRUCTING LASER  
DEVICES A65-23847
- GAS CONSTITUTION OF HELIUM-NEON LASER DISCHARGE  
ANALYZED, CONSIDERING SPECTRUM LINE RELATIVE  
INTENSITIES IN LIGHT EMITTED FROM DISCHARGE TUBE  
A65-30333
- TIME-VARIATION AND SPONTANEOUS EMISSION FROM HE-  
HG DISCHARGE OF 6149 ANGSTROM LASER TRANSITION  
A65-31451
- WHITE LIGHT EMISSION WHEN PULSED LASER BEAM  
FOCUSES ON TARGETS IS MAINLY DUE TO TEMPERATURE  
RADIATION A65-34957
- SECOND HARMONIC LIGHT GENERATION, STRESSING  
SATURATION EFFECTS OCCURRING AT HIGH LASER POWER  
LEVELS, SOLVING NONLINEAR COUPLED MAXWELL  
EQUATIONS A66-11443
- STIMULATED EMISSION IN INDIUM ARSENIDE SHOWS  
EXCITATION THRESHOLD LOW AND LIGHT EMISSION HIGHLY  
DIRECTIONAL A66-17026
- FORCED EMISSION FROM ELECTRON-EXCITED CADMIUM  
SELENIDE A66-22174
- LIGHT EMISSION FROM GALLIUM ARSENIDE SEMICONDUCTOR  
P-N JUNCTION INJECTION LASER
- NOTS-TP-3655 N66-19703
- LIGHT INTENSITY**  
GAS LASER CROSS MODULATION EFFECT WHEN EXPOSED TO  
FLASH TUBE RADIATION A65-15324
- LIGHT INTENSITY DISTRIBUTION INSIDE CYLINDRICAL  
REFLECTING CAVITY USING RUBY LASER ROD AND  
ANALYSIS OF INTERDEPENDENCE OF THRESHOLD, FILAMENT  
POSITION AND EFFICIENCY A65-22624
- THRESHOLD INTENSITY OF 8400 ANGSTROM LIGHT FROM  
GALLIUM ARSENIDE LASER DIODE AND EYE DAMAGE  
A65-34663
- INTENSITY OF POLARIZED LIGHT TRANSMITTED THROUGH  
LASER AMPLIFIER AND LINEAR POLARIZER, AS FUNCTION  
OF AXIAL MAGNETIC FIELD STRENGTH A66-17292
- LIGHT MODULATOR**  
BEHAVIOR OF COUPLING-TYPE INTERNAL LASER  
MODULATORS WITH BANDWIDTH COMPARABLE TO MODE  
SPACING A65-16404
- GENERATION OF SINGLE FREQUENCY LIGHT USING FM  
LASER A65-16670
- MULTIMODE LASER OSCILLATION RESULTING FROM  
MODULATION OF DIELECTRIC CONSTANT AND OF LOSS OR  
GAIN OF LASER MEDIUM A65-17652
- HELIUM-NEON LASER MODULATION BY POSITIVE AND  
NEGATIVE VOLTAGE PULSES A65-35931
- LASERS AND LASER SPECTROSCOPY - LIGHT MODULATION  
AND DEMODULATION METHODS, LASER TRANSITIONS,  
RAMAN EFFECT INITIATION, AND NONLINEAR OPTICAL  
PHENOMENA  
TR-A-34 N65-19791
- LIGHT MODULATION AND LASER TELECOMMUNICATIONS  
NASA-TT-F-8762 N65-32178
- PERIODIC VARIATION OF QUALITY FACTOR OF HE- NE  
GAS LASER CAVITY BY VIBRATING QUARTZ-MODULATION OF  
LIGHT BEAM A66-13477
- MODULATION OF LASER LIGHT WITH COMPOSITE FABRY-  
PEROT RESONATOR, USING MORE THAN THREE MULTIPLE  
REFLECTING PLATES A66-15836
- GADOLINIUM MOLYBDENATE AS FERROELECTRIC HOST IN  
PULSED LASER, NOTING LIGHT MODULATION AND CRYSTAL  
COMAIN A66-23207
- LIGHT PRESSURE**  
PLASMA PRODUCTION USING GIANT LASERS FOCUSED ON  
SMALL SPECKS OF SOLID MATERIAL A65-30792
- LIGHT SCATTERING**  
RELATIVITY VELOCITY SENSING TECHNIQUE FOR MOVING  
VEHICLE BY LASER LIGHT BACKSCATTERED FROM SURFACE  
A65-14934
- FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS  
SYSTEMS, PRIMARILY LIGHT ABSORPTION AND  
ATMOSPHERIC SCATTERING A65-15349
- NOBLE GAS MOLECULAR SCATTERING OF RUBY LASER LIGHT  
COMPARED WITH RAYLEIGH THEORY A65-15438
- BRILLOUIN SCATTERING IN LIQUIDS EXCITED BY HE- NE  
MASER AND OBSERVED BY FABRY- PEROT  
INTERFEROMETER, NOTING ACOUSTIC WAVE VELOCITY AND  
LINE BROADENING A65-15699
- STIMULATED COMBINATION LIGHT SCATTERING WITHIN AND  
OUTSIDE RESONATOR CAVITY BASED ON LASER  
DEVELOPMENT A65-16627
- STATISTICAL DISTRIBUTION OF ARRIVAL ANGLE, SPOT  
LOCATION, AMPLITUDE, ETC., OF LASER BEAM TRAVERSING  
TURBULENT ATMOSPHERE A65-24931
- LIGHT DIFFRACTION BY GRATING DUE TO FARADAY AND  
KERR EFFECT IN ELECTROMAGNETIC FIELD OF LASER  
BEAM A65-26582

## SUBJECT INDEX

## LIGHT SOURCE

MULTICHANNEL PHOTOELECTRIC SPECTRUM ANALYZER WITH  
KERR CELL GATING RECORDS SPECTRUM OF LASER LIGHT  
SCATTERED FROM SINGLE GIANT PULSE IN PLASMA

A65-28203

MAGNETIC FIELD PROBE IN ELECTROMAGNETICALLY DRIVEN  
SHOCK TUBE AND COHERENT LIGHT IN IONIZING SHOCK  
WAVE PLASMA DIAGNOSTICS

A65-29569

FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS  
SYSTEMS, PRIMARILY LIGHT ABSORPTION AND  
ATMOSPHERIC SCATTERING

A65-32353

LOW ANGLE SCATTERING AND INTERFEROGRAPHIC  
MEASUREMENTS USED IN EVALUATING RUBY LASER RODS

A65-33416

RADIATION SCATTERING FACTOR DETERMINATION FOR RUBY  
LASER

A65-36013

LIGHT SCATTERING IN SEA WATER - FORWARD SCATTERING  
OF LASER BEAM IN SEA WATER AND FORTRAN PROGRAM  
SCATTERING CALCULATIONS

AD-610126

N65-23316

CONTINUOUS WAVE GAS LASER AND HIGH SPEED MOTION  
PICTURE CAMERA FOR DETECTION OF NEARLY  
CONTINUOUS SET OF LIGHT SCATTERING PHOTOGRAPHS  
FROM POLYETHYLENE POLYMER SAMPLE

OMR-TR-77

N65-25399

MOLECULAR SCATTERING OF LIGHT USING RUBY LASER  
SOURCE

CEA-R-2375

N65-32985

MEASUREMENT OF LASER BEAM LIGHT SCATTERED BY  
ATMOSPHERE

NASA-CR-67498

N65-36393

INTERFERENCE EFFECTS AT THIN TRANSPARENT  
CYLINDRICAL GLASS FIBERS EXPOSED TO COHERENT LIGHT  
FROM HE-NE LASER

A66-10368

TWO-DIMENSIONAL LASER DEFLECTION USING FOURIER  
OPTICS

A66-10897

ANGULAR WIDTH AND INTENSITY OF LIGHT FROM TWO  
LASERS THAT CAUSE PLASMA TO OSCILLATE AND IN TURN  
ARE SCATTERED BY INDUCED FLUCTUATIONS

A66-14328

LOCAL ELECTRON TEMPERATURE AND ELECTRON DENSITY IN  
THETA PINCH MEASURED BY MEANS OF SCATTERING OF  
LASER BEAM

A66-14334

THOMSON SCATTERING MEASUREMENTS OF MAGNETIC  
ANNULAR SHOCK TUBE PLASMAS USING Q-SWITCHED RUBY  
LASER LIGHT BEAM

A66-14707

VARIATION OF SCATTERING CROSS SECTION WITH BEAM  
INTENSITY FOR RUBY LASER LIGHT ON ATOMIC HYDROGEN

A66-15864

LASER-BEAM SCATTERING BY INDIVIDUALLY INTRODUCED  
CHARGED POLYSTYRENE SPHERICAL PARTICLES AND  
DROPLETS OF NAPHTHALENE AND WATER IN COMBINATION

A66-17473

DIFFRACTION VELOCIMETER DETECTING AND MEASURING  
TRANSVERSE MOVEMENT OF SURFACE BY SENSING LIGHT  
BACKSCATTERED BY IT WHEN LASER ILLUMINATED

A66-18333

BRILLOUIN SCATTERING OF LIGHT BY PHONONS AND  
PHONON MASER IN DERIVATION OF CONSERVATION  
THEOREMS FROM BASIC EQUATIONS

A66-18397

APPARATUS FOR FLUORIDATION OF HYDROXYL AND OXYGEN  
CONTAMINATED FLUORIDE COMPOUNDS, OBTAINING  
OPTICALLY CLEAR CRYSTALS WITH NO TYNDALL  
SCATTERING FOR LASER APPLICATION

A66-18488

LOWER ATMOSPHERIC DENSITY MEASUREMENTS THROUGH  
LIGHT SCATTERING FROM Q-SPOILED RUBY LASER BEAM,  
USING OPTICAL RADAR DETECTOR

A66-20398

QUANTUM THEORY OF INTERACTION OF ELECTROMAGNETIC  
WAVES IN PLASMA CONSIDERED IN TERMS OF LIGHT-

LIGHT SCATTERING AND PLASMA-LASER BEAM INTERACTION

A66-21173

DIFFUSION OF LIGHT BY PLASMA ELECTRONS PRODUCED IN  
LABORATORY FOR VERY SMALL EFFECTIVE DIFFUSION AREA

A66-21712

SOVIET AND FOREIGN PAPERS ON PLASMA DIAGNOSTICS BY  
SCATTERING OF LASER BEAMS AT PLASMA ELECTRONS

A66-21990

OPTICAL DIFFRACTION VELOCIMETER, USING  
BACKSCATTERED LASER LIGHT TO MEASURE RELATIVE  
VELOCITY BETWEEN LIGHT SOURCE AND SURFACE

A66-22958

LASER SCATTERING BY BOUND CHARGED PARTICLES

A66-23080

EARTH ATMOSPHERE PROPERTIES INVESTIGATION BASED ON  
LASER BEAM BACKSCATTERING MEASUREMENTS

NASA-CR-70177

N66-16967

ELECTRON TEMPERATURE AND DENSITY MEASUREMENTS OF  
26 K JOULE THETA-PINCH BY LIGHT SCATTERING  
FROM COMBINED OSCILLATOR-AMPLIFIER LASER

IPP-1/42

N66-21141

## LIGHT SOURCE

CHROMIUM INDUCED LIGHT DISPERSION IN R LINES OF  
RUBY, NOTING REFRACTION SHIFT IN LASER SPECTRUM

A65-20260

CONTINUOUS OUTPUT GAS-PHASE LASERS AS SMALL  
BANDWIDTH SOURCES OF LIGHT FOR OPTICAL  
DIFFRACTOMETERS

A65-22206

GAS LASER AS LIGHT SOURCE FOR MACH ZEHNDER  
INTERFEROMETER AS COMPARED TO MERCURY VAPOR LAMP

A65-22949

INTERFEROMETER USING SMALL DIFFRACTION GRATING AND  
GAS LASER LIGHT SOURCE IN SCHLIEREN SYSTEM FOR  
FLUID MECHANICS RESEARCH

A65-25332

PINCH METHODS OF GAS DISCHARGE AS LIGHT SOURCE FOR  
OPTICAL PUMPING OF VARIOUS LASER MATERIALS

N65-22742

GASEOUS AND RUBY LASERS AS LIGHT SOURCES FOR  
PHOTOELASTICITY

TEAM-276

N65-29794

MOLECULAR SCATTERING OF LIGHT USING RUBY LASER  
SOURCE

CEA-R-2375

N65-32985

REAL TIME, PROJECTION DISPLAY SYSTEM USING LASER  
LIGHT SOURCE

U1-903600-1

N65-35989

SOLID STATE LASERS - PROBLEMS OF CONTINUOUS  
STIMULATED EMISSION IN SOLIDS, MATERIALS, LIGHT  
SOURCES, COOLING, AND APPLICATIONS

N65-36116

ADVANTAGES OF GAS LASERS AS LIGHT SOURCES IN  
AERODYNAMIC RESEARCH INTERFEROMETERS

A66-16944

CONVENTIONAL FLOW VISUALIZATION USING LASER LIGHT  
SOURCE

AIAA PAPER 66-127

A66-17104

REVIEW OF NONLINER PHENOMENA RELATIVE TO RESEARCH  
WITH INTENSE LIGHT SOURCES - LASERS

REPT.-65GL94

N66-11935

DEVELOPMENT OF SEMICONDUCTOR LIGHT SOURCES WITH  
RUBY LASERS AND ZINC-DOPED GA AS JUNCTION  
DIODES

REPT.-6400-42-T

N66-12450

OPTICAL MARGINAL OSCILLATOR DEVELOPMENT IN  
RESEARCH TOWARD TUNABLE COHERENT LIGHT SOURCE

REPT.-8071

N66-14034

DYNAMIC STRESS CONCENTRATION USING PHOTOELASTICITY  
AND RUBY LASER LIGHT SOURCE

- TEAM-285 N66-20850
- LIGHT TRANSMISSION**
- LASER BEAM BEYOND-HORIZON COMMUNICATION BY MEANS OF CLOUD AND HAZE SCATTERING A65-19596
- VIGNETTING TEST FOR MIRROR TELESCOPE USING CW LASER A65-25826
- TRANSMISSION OF HIGH-POWER LASER LIGHT FOR DIELECTRIC TUBES AND RODS A65-29164
- PHOTOGRAPHIC STUDY OF Q-SWITCHED LASER BEAM PROPAGATING OVER 10-MILE PATH A65-31044
- GREEN LASER LIGHT TRANSMISSION THROUGH WATER NOLTR-64-179 N65-20605
- MULTIPLE LIGHT FILTER NARROWING EMISSION BANDS OF RUBY LASER WITH MULTIPLEX RESONATOR A66-12627
- MOLECULAR ANISOTROPY OF PROPAGATION OF INTENSE LIGHT BEAM, NOTING RAMAN AND BRILLOUIN EFFECTS A66-15106
- TRANSMISSION THROUGH TAPERED QUARTZ TUBE IN LASER NEAR FIELD A66-15481
- SECOND HARMONIC LIGHT GENERATED ON REFLECTION OF GIANT-PULSE LASER BEAM FROM SURFACE OF SILVER MIRROR A66-16072
- PHOTON TRAPPED WAVE EFFECT FOR DEVELOPING OPTICAL WAVEGUIDES IN WHICH OPTICAL BEAM CREATES WAVEGUIDE AS IT PROPAGATES A66-16662
- IRREGULAR BENDS AND LENS DISPLACEMENTS EFFECT ON WAVELENGTH AND MODES IN LASER WAVEGUIDE A66-23103
- MODULATING OUTPUT OF SOLID-STATE LASERS D-920259-12 N66-12814
- TRANSMISSION CHARACTERISTICS OF NEODYMIUM LASER N66-16812
- LIGHTING EQUIPMENT**
- ADAPTABILITY OF LASERS TO SCHLIEREN SYSTEMS - PHOTOGRAPHIC LIGHTING SYSTEMS ARL-65-139 N66-14801
- LIGHTNING**
- COMBUSTION INSTABILITY, BALL LIGHTNING, SOLAR ACTIVITY, NOCTILUCENT CLOUDS, INTERSTELLAR COMMUNICATIONS, NEODYMIUM LASER, AND HYDROFOILS N65-34075
- LINE SPECTRUM**
- LINE WIDTHS AND INVERSION RATIOS OF IRON DOPED RUTILE FOR SUITABILITY IN BROADBAND MASERS A65-19622
- LASER RADIATION ABSORBED ALONG SLANT PATHS, SPECTRAL LINE OVERLAPPING AND CENTER LINE SHIFT WITH PRESSURE VARIATION A66-17295
- PHOTOLUMINESCENCE LINE STRUCTURE OF ZINC SULFIDE AND CADMIUM SULFIDE CRYSTALS DOPED WITH RARE EARTHS - LASER MATERIALS N66-16741
- LIQUID**
- IMMERSION LIQUIDS FOR HIGH ENERGY RUBY LASERS WITH MATCHING REFRACTIVE INDEXES TRANSPARENT AT RUBY PUMPING AND LASING WAVELENGTHS A65-22625
- LASER RESEARCH IN U.S.S.R., COMBUSTION INSTABILITY IN LIQUID ROCKET AND AIR BREATHING PROPULSION, GAS DYNAMICS AND PROPERTIES AT HIGH TEMPERATURE, AND MORPHOLOGICAL FORMS IN POLYMERS AD-460286 N65-23836
- STIMULATED BRILLOUIN SCATTERING OF INTENSE LASER LIGHT WITH BUILD-UP OF COHERENT HYPERSONIC WAVES IN LIQUIDS NASA-CR-58214 N65-33710
- LIQUID INJECTION**
- BUILDUP AND DECAY TRANSIENT EFFECTS IN GAS LASERS
- DUE TO LIGHT ABSORPTION BY INSERTED LIQUID SAMPLES A65-15816
- LIQUID LASER**
- BRILLOUIN SCATTERING IN LIQUIDS EXCITED BY HE- NE MASER AND OBSERVED BY FABRY- PEROT INTERFEROMETER, NOTING ACOUSTIC WAVE VELOCITY AND LINE BROADENING A65-15699
- LASER ACTION IN RARE EARTH CHELATES, EMPHASIZING CHEMISTRY AND SPECTROSCOPIC PROPERTIES OF MATERIALS AND PROPERTIES OF LIQUID LASER A65-20074
- EMISSION SPECTRA OF TRIS AND TETRAKIS FORMS OF FOUR BETA-DIKETONE EUROPIUM CHELATES STUDIED FOR LIQUID LASER APPLICATION A65-33308
- FOUR-LEVEL, GAS, LIQUID, SEMICONDUCTOR, AND RUBY LASERS RSIC-195 N65-24836
- HEAVY WATER USED AS LIQUID LASER SOLVENT FOR HIGH RADIANCE LIQUID LASER SYSTEMS AND RESEARCH IN CUTPUT BEAM DIVERGENCE, SPECTRAL NARROWING, AND THRESHOLDS FOR LASER ACTION AD-610714 N65-27886
- THEORETICAL OPTICAL RESONATOR FOR LASER WITH RARE EARTH LIQUID SOLUTIONS AS ACTIVE COMPONENTS A66-21970
- EMISSION SPECTROSCOPY AND COORDINATION CHEMISTRY OF EUROPIUM CHELATE SOLUTIONS - CHELATE LASERS INVESTIGATED FOR EVALUATING POTENTIALITIES OF LIQUID LASERS TR-65-052-11 N66-14177
- COORDINATION AND CHEMICAL EQUILIBRIUM IN CHELATE LASER MATERIALS N66-20730
- LIQUID NITROGEN**
- LASER ACTION IN ALLOYED GALLIUM ARSENIDE JUNCTION DIODE SUBMERGED IN LIQUID NITROGEN A65-29198
- LITHIUM ALLOY**
- CONTINUOUS OPTICAL SECOND-HARMONIC GENERATION USING ND/YAG LASER AND CRYSTAL OF SINGLE-DOMAIN LITHIUM NIOBATE A66-16378
- LITHIUM COMPOUND**
- VELOCITY MATCHED SECOND HARMONIC GENERATION / SHG/ AND MIXING OBTAINED IN PIEZOELECTRIC LITHIUM NIOBATE CRYSTALS A65-19235
- LOAD FACTOR**
- EFFECT OF LOAD MISMATCH ON LASER OUTPUT, DETERMINING NONLINEAR DEPENDENCE OF EQUIVALENT NEGATIVE CONDUCTANCE AS FUNCTION OF OSCILLATION AMPLITUDE IN LASER RESONATOR CAVITY A66-20435
- LOGIC CIRCUIT**
- SEMICONDUCTOR LASER DIGITAL DEVICES FOR GENERAL PURPOSE LOGIC CIRCUITS BASED ON NONLINEAR INTERACTION OF INTENSE OPTICAL SIGNALS A65-19342
- LORAN C**
- ATOMIC HYDROGEN MASER FOR TIME AND FREQUENCY MEASUREMENTS - TIME COMPARISONS ON MASERS WITH LORAN C N65-26678
- DIRECT FREQUENCY COMPARISON OF ATOMIC HYDROGEN MASERS IN DIFFERENT PLACES AND CONDITIONS BY SIMULTANEOUS MONITORING OF LORAN C SIGNALS A66-24145
- LORENTZ FORCE**
- TRAVELING FIELDS IN INTERACTION OF IONIZED GASES WITH ELECTROMAGNETIC FIELD CURRENTS CHECKING LORENTZ FORCE AND MAGNETIC INDUCTION A66-12980
- LOWER ATMOSPHERE**
- LOWER ATMOSPHERIC DENSITY MEASUREMENTS THROUGH LIGHT SCATTERING FROM Q-SPOILED RUBY LASER BEAM, USING OPTICAL RADAR DETECTOR A66-20398

## SUBJECT INDEX

## MAGNETISM

- LOWER ATMOSPHERE ABSORPTION SPECTRUM STRUCTURE  
FROM 8512 TO 11600 A - NEODYMIUM LASER SPECTRUM  
NRL-6352 N66-17604
- LUNAR PHOTOGRAPH  
GEODETIC SATELLITE, CALIBRATION SATELLITE, LASER  
GEODESY, AIRBORNE GRAVITY METER, LUNAR MOTION  
AND GRAVITY, AND BALLOON-BORNE LUNAR PHOTOGRAPHS  
AFCRL-65-14 N65-22221
- LUNAR TOPOGRAPHY  
MOON SHAPE DETERMINED BY MEASURING DISTANCE FROM  
LUNAR SURFACE POINTS TO LUNAR CENTER OF MASS,  
USING OPTICAL LASER RADAR A66-22964
- M**
- MACH-ZEHNDER INTERFEROMETER  
HE- NE GAS LASER APPLICATION TO SCHLIEN  
PHOTOGRAPHY AND MACH- ZEHNDER INTERFEROMETRY IN  
AERODYNAMIC TESTING A65-22501
- GAS LASER AS LIGHT SOURCE FOR MACH ZEHNDER  
INTERFEROMETER AS COMPARED TO MERCURY VAPOR LAMP  
A65-22949
- NEON-HELIUM GAS LASER APPLICATION TO SCHLIEN  
PHOTOGRAPHY AND MACH- ZEHNDER INTERFEROMETRY  
FOR USE IN AERODYNAMIC TESTING N65-21372
- MACH- ZEHNDER LASER INTERFEROMETER AS DIAGNOSTIC  
TOOL IN SHOCK TUBE EXPERIMENTS A66-23352
- MACHINING  
INDUSTRIAL APPLICATION OF RUBY AND NEODYMIUM  
LASERS INCLUDE SUPERHARD MATERIAL MACHINING AND  
METALLURGY A65-18120
- LASER BEAM MACHINING AND DRILLING TECHNIQUES FOR  
USE ON ANY MATERIAL REGARDLESS OF THERMAL  
PROPERTIES A65-25373
- LASERS FOR MACHINING AND WELDING, NOTING  
PARTICULARLY HE- NE PULSED LASER A65-30540
- MICROMACHINING WITH PULSED HELIUM-NEON GAS LASER,  
NOTING EXPERIMENTAL TECHNIQUES, OPERATION AND  
APPLICATION A66-19734
- MAGNESIUM FLUORIDE  
CRYSTAL GROWTH, LATTICE CONSTANT, AND DENSITY OF  
MAGNESIUM POTASSIUM FLUORIDE AND BARIUM  
ZIRCONATE  
AD-623511 N66-14467
- MAGNETIC COIL  
MULTICOIL SUPERCONDUCTING MAGNETS FOR BROADBAND  
TRAVELING WAVE MASERS  
NASA-CR-386 N66-18174
- MAGNETIC CONTROL  
TRAVELING WAVE MASER EMPLOYING MAGNETIC STAGGER  
TUNING IN SMALL COMPACT SUPERCONDUCTING MAGNET  
ACHIEVES TRADING EXCESS ELECTRONIC GAIN FOR  
BANDWIDTH A65-29196
- MAGNETIC DISPERSION  
DISPERSION EFFECTS IN LASER AMPLIFIERS  
AFOSR-65-2211 N66-16411
- MAGNETIC EFFECT  
MODEL FOR BEHAVIOR OF OPTICAL MASER IN STATIC  
MAGNETIC FIELD OF ARBITRARY STRENGTH IN Z  
DIRECTION AND IN ELECTROMAGNETIC FIELD COMPOSED OF  
TRAVELING WAVES A66-13135
- MAGNETIC FIELD  
OUTPUT OF SINGLE MODE GAS LASER IN AXIAL MAGNETIC  
FIELD STUDIED FOR INCREASE IN FREQUENCY STABILITY  
A65-26954
- EQUATIONS DESCRIBING HEAT FREQUENCY VARIATION AND  
MODE COMPETITION IN GASEOUS LASER OPERATED IN  
MAGNETIC FIELD PARALLEL TO LASER AXIS A65-30303
- RUBY LASER MODULATION AT ATOMIC LEVEL - FREQUENCY  
SHIFT MEASUREMENT OF LASER EMISSION UNDER
- INHOMOGENEOUS MAGNETIC FIELD BY SPECTROSCOPY  
NASA-CR-57464 N65-19863
- LASER MODULATION AT ATOMIC LEVEL - YTTRIUM-  
ALUMINUM GARNET EMISSION AND LASER EMISSION  
SHIFT WITH HOMOGENEOUS PULSED MAGNETIC FIELD  
NASA-CR-57823 N65-21308
- HIGH POWER MERCURY LASER OPERATIONS IN KRYPTON AND  
ARGON AS FUNCTION OF MAGNETIC FIELD  
CPR-2 N65-22323
- LOW FREQUENCY MAGNETIC FIELD SENSOR - PROTON  
MASER ANTENNA DESIGN CONSTRUCTION AND  
PERFORMANCE  
RADC-TR-64-567 N65-32211
- HIGH POWER RELAXATION OSCILLATION IN MULTILEVEL  
SOLID STATE RUBY MASER DUE TO MAGNETIC FIELD  
MODULATION A66-13327
- DESIGN AND OPERATION OF HELIUM-NEON LASER NOTING  
RADIATION, FREQUENCY STRUCTURE, POWER DENSITY,  
EXTERNAL MAGNETIC FIELD EFFECT, APPLICATION, ETC  
A66-22980
- MAGNETIC FIELD INTENSITY  
INTENSITY OF POLARIZED LIGHT TRANSMITTED THROUGH  
LASER AMPLIFIER AND LINEAR POLARIZER, AS FUNCTION  
OF AXIAL MAGNETIC FIELD STRENGTH A66-17292
- DEPENDENCE OF EMISSION INTENSITY OF GAS LASER ON  
LONGITUDINAL AND TRANSVERSE MAGNETIC FIELDS, USING  
SIMPLIFIED MODEL A66-24885
- MAGNETIC MATERIAL  
WIDE TUNING RANGE L-BAND TRAVELING WAVE MASER  
NOTING SLOW WAVE STRUCTURE AND ISOLATOR MATERIAL  
A66-12441
- RESONATOR MADE OF MAGNETIC MATERIALS FOR TUNING  
MOLECULAR GENERATOR BY ZEEMAN MODULATION  
A66-20792
- MAGNETIC PUMPING  
LASER RESEARCH ACTIVITIES IN CHINESE PEOPLES  
REPUBLIC - FORMATION OF MICROWAVE MASER BY  
LASER PUMPING, AND FORMATION TIME OF GAS LASER  
OSCILLATIONS  
JPRS-33323 N66-15048
- FORMATION OF MICROWAVE MASER BY PUMPING OF LOW  
TEMPERATURE RUBY LASER N66-15049
- MAGNETIC RESONANCE  
MICROWAVE PROPERTIES PARTICULARLY LINEWIDTH AND  
MAGNETIC ANISOTROPY IN CALCIUM-VANADIUM BISMUTH  
GARNET, NOTING TWM ISOLATOR A65-24964
- INERTIAL SENSORS REVIEWING RING LASER,  
ELECTROSTATIC FLUID SPHERE, MAGNETIC RESONANCE,  
SUPERCONDUCTIVITY GYROSCOPE, RELATIVISTIC ROTATING  
TENSOR, VORTEX RATE AND QUANTUM MECHANICAL EFFECT  
SENSING  
AIAA PAPER 65-401 A65-29669
- QUANTUM RF PHYSICS TEXT COVERING MAGNETIC  
RESONANCE THEORY, ELECTRON PARAMAGNETIC RESONANCE,  
NUCLEAR MAGNETIC RESONANCES, TWO- AND THREE-LEVEL  
MASERS, RF GAS SPECTROSCOPY AND AMMONIA  
OSCILLATOR A66-10954
- MAGNETIC SIGNAL  
GAIN SATURATION OF RUBY MASER BY NEARBY  
INTERFERING SIGNAL DERIVED FROM MOTION EQUATION OF  
DENSITY MATRIX A66-19933
- MAGNETISM  
SOLID STATE DEVICE, LASER, MATERIALS, BAND  
STRUCTURE AND SPECTROSCOPY OF SOLIDS, AND  
MAGNETISM AND RESONANCE RESEARCH  
ESD-TDR-64-560 N65-16944
- LASER, MATERIALS, AND SOLID STATE RESEARCH, BAND  
STRUCTURE AND SOLIDS SPECTROGRAPHY, AND  
MAGNETISM AND RESONANCE  
ESD-TCR-64-349 N65-19816



- SOLID STATE RESEARCH REPORT INCLUDING SOLID STATE DEVICES, LASERS, MATERIALS, BAND STRUCTURE, MAGNETISM AND RESONANCE, AND SPECTROSCOPY OF SOLIDS  
ESD-TDR-65-31 N65-25537
- MAGNETO-OPTIC**  
HELIUM-NEON GAS LASER AS LIGHT SOURCE FOR MAGNETO-OPTICAL APPARATUS - KERR MAGNETO-OPTICAL EFFECT OF FERROMAGNETIC IRON-NICKEL THIN FILM  
N65-26766
- MAGNETOHYDRODYNAMIC GENERATOR**  
SUPERCONDUCTORS APPLIED TO MAGNETS, LASERS AND MHD POWER GENERATION  
A66-20674
- MAGNETOPLASMA**  
MAGNETIC FIELD PROBE IN ELECTROMAGNETICALLY DRIVEN SHOCK TUBE AND COHERENT LIGHT IN IONIZING SHOCK WAVE PLASMA DIAGNOSTICS  
A65-29569
- MAMMAL**  
RETINAL VASCULATURE OF RABBIT AND MONKEY AS AFFECTED BY LASER IRRADIATION PROXIMITY OF PIGMENT EPITHELIUM, BLOOD FLOW, AND AMOUNT OF REDUCED HEMOGLOBIN  
A66-80470
- MANNED SPACE FLIGHT**  
GIANT RADIO TELESCOPE TO DETECT EXTRATERRESTRIAL RADIATION, RAMAN SCATTERING LASERS, FORECASTING SOLAR FLARES FOR MANNED SPACE FLIGHT, VOSKHOD II LIFE SUPPORT, AND ALUMINUM NITRIDE FILMS  
N65-32675
- MANUFACTURING**  
LASER APPLICATION IN MEDICINE, MANUFACTURING, SPECTROSCOPY, OPTICS AND COMMUNICATIONS  
A65-31882
- MARS /PLANET/**  
LECTURE MANUSCRIPTS ON HIGH ALTITUDE EXPLOSIONS, BIOLOGICAL EXPLORATION OF MARS, MASERS AND LASERS, PLANETARY ATMOSPHERES, RELATIVITY THEORY, ELEMENT ABUNDANCE, AND SOLAR PARTICLES  
N65-31360
- MARS SPACECRAFT**  
SPACE COMMUNICATION REQUIREMENTS USING LASERS AND MICROWAVES IN MANNED MARS FLIGHTS  
AIAA PAPER 65-324 A65-30519
- MASER OUTPUT**  
SPECTRAL LINE SHAPE FOR FABRY- PEROT MASER USING VARIOUS OSCILLATION MODES  
A65-14113
- SELF-PULSED MODULATION MODE STABILIZATION OF TWO-LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE FEEDBACK  
A65-14144
- TRANSITION PROCESSES OF OSCILLATION AMPLITUDE FORMATION IN RF THREE-LEVEL MASERS  
A65-15460
- THRESHOLD CONDITIONS FOR CONTINUOUS SELF-SUSTAINED OSCILLATIONS PRODUCED BY REGENERATIVE RUBIDIUM GAS MASER  
A65-17659
- THERMAL AND SHOT NOISE EFFECTS ON AMPLITUDE AND FREQUENCY OSCILLATIONS OF MOLECULAR BEAM MASER  
A65-19682
- IMPROVED MASER PERFORMANCE THROUGH GAIN STABILITY IF PUMP FLUCTUATIONS ARE KEPT TO MINIMUM BY ELIMINATION OF TWO OF FOUR VARIABLES  
A65-21324
- SELF-SUSTAINED OSCILLATION OBTAINED IN OPTICALLY PUMPED RUBIDIUM MASER OPERATING AT TRANSITION FREQUENCY OF 6835 MC  
A65-21873
- MASER PEAK PULSE CHARACTERISTICS DURING INSTANTANEOUS SWITCHING OF INTERFEROMETER WHEN LOSS FACTOR RAPIDLY DECREASES  
A65-23004
- SOLID STATE MICROWAVE MASER ACTION AT 77.4 DEGREES K WITH BROADBANDING TECHNIQUE APPLIED TO INCREASE GAIN-BANDWIDTH PRODUCT, EXAMINING RUBY MATERIAL AND HIGH Q MICROWAVE CAVITIES  
A65-23155
- CHROMIUM-DOPED RUTILE MASER INVERSION RATIO CROSS RELAXATION EFFECT OPERATING AT LIQUID NITROGEN TEMPERATURES  
A65-23385
- SELF-PULSED MODULATION MODE STABILIZATION OF TWO-LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE FEEDBACK  
A65-24019
- BEAM MASER EXCITATION PARAMETER CALCULATIONS INCLUDING COLLISION IN BEAM EFFECTS AND COMPARISON WITH MOLECULAR FORMALDEHYDE  
A65-24825
- SPECTRAL LINE SHAPE FOR FABRY- PEROT MASER USING VARIOUS OSCILLATION MODES  
A65-24933
- PUMP FREQUENCY OF 30 GIGACYCLES USING HARMONIC CROSS RELAXATION ON CHROMIUM DOPED RUTILE TO OBTAIN POPULATION INVERSION AT 40 GIGACYCLE SIGNAL FREQUENCY  
A65-25873
- ATOMIC HYDROGEN MASER FOR MEASURING RF AND MICROWAVE SPECTRAL LINES DISCUSSING THRESHOLD, RELAXATION, FREQUENCY STABILITY AND HYPERFINE STRUCTURE  
A65-26934
- MASER AND LASER PROPERTIES INCLUDING RADIATION FIELD AND MASER MEDIA, NOTING MOLECULAR AMPLIFICATION CENTERS AND ENGINEERING PROBLEMS  
A65-26935
- TRANSITION PROCESSES OF OSCILLATION AMPLITUDE FORMATION IN RF THREE-LEVEL MASERS  
A65-28556
- HYDROGEN MASER RESETTABILITY VERIFYING BY MEASURING MASER OUTPUT FREQUENCY AGAINST HYDROGEN PRESSURE, CONSIDERING EXCHANGE COLLISION AND WALL INTERACTIONS  
A65-29119
- QUANTUM MECHANICS OF SIGNALS AND NOISE IN ATTENUATORS AND MASER AMPLIFIERS, RELATING EXPECTATION VALUES AND THERMAL STATE OF SYSTEM  
A65-30510
- NOISE OUTPUT AND NOISE FACTOR OF OVERLOADED MASER AMPLIFIERS STUDIED AS FUNCTION OF SMALL-SIGNAL GAIN VS ACTUAL GAIN  
A65-31032
- RADIO STATION FACILITIES AT RAISING, WEST GERMANY NOTING SATELLITE COMMUNICATION, MASER RECEIVING SYSTEM, PARABOLIC ANTENNAS, ETC  
A65-35195
- OPTICAL MASER OUTPUT POWER AFFECTED BY GAS MIXTURE AND PRESSURE, RESONATOR GEOMETRY, AND MIRROR REFLECTIVITY FOR PLASMA RESEARCH  
N65-23495
- ALUMINUM NITRATE POWDER MASER DOPED WITH FERRIC IONS OPERATION IN X-BAND WITHOUT EXTERNAL DC MAGNETIC FIELD  
A66-11374
- EMISSION SPECTRUM OF RUBY MASER CALCULATED, USING DYNAMICS OF TWO-LEVEL SYSTEMS  
A66-16541
- DIRECT FREQUENCY COMPARISON OF ATOMIC HYDROGEN MASERS IN DIFFERENT PLACES AND CONDITIONS BY SIMULTANEOUS MONITORING OF LORAN C SIGNALS  
A66-24145
- LASER RESEARCH ACTIVITIES IN CHINESE PEOPLES REPUBLIC - FORMATION OF MICROWAVE MASER BY LASER PUMPING, AND FORMATION TIME OF GAS LASER OSCILLATIONS  
JPRS-33323 N66-15048
- FORMATION OF MICROWAVE MASER BY PUMPING OF LOW TEMPERATURE RUBY LASER  
N66-15049
- MILLIMETER AND SUBMILLIMETER MASER DEVICES - IRON-COPED MASER AMPLIFIER, PUSH-PULL RUTILE MASER, AND X-BAND ZERO FIELD MASERS  
REPT.-490H N66-16210
- COMPARISON OF HYDROGEN MASER AND OF CESIUM BEAM TUBE FREQUENCY STANDARD  
NASA-TN-D-3292 N66-21698

## MASER RESONATOR

MASER AMPLIFIER WITH COUPLED ACTIVE RESONATORS  
OPERATING AT 21 CM WAVELENGTH, NOTING ADVANTAGE  
OVER PASSIVE INPUT CIRCUIT A65-14136

QUANTUM ACTIVE PARAMAGNETIC AMPLIFIER IN FORM OF  
SERIES-COUPLED RESONATORS, NOTING BANDWIDTH  
DEPENDENCE ON RESONATOR NUMBER AND DECOUPLING  
INDEPENDENCE A65-14137

NORMAL BOLTZMANN DISTRIBUTION INVERSION IN  
MOLECULAR BEAM TO OBTAIN EXCESS UPPER ENERGY  
LEVEL POPULATION FOR MASER OSCILLATION A65-15801

SELF-CONSISTENT FIELD ANALYSIS FOR FIELD  
DISTRIBUTIONS OF RESONANT MODES IN SPHERICAL  
MIRROR FABRY-PEROT RESONATOR A65-16566

MASER AMPLIFIER WITH COUPLED ACTIVE RESONATORS  
OPERATING AT 21 CM WAVELENGTH, NOTING ADVANTAGE  
OVER PASSIVE INPUT CIRCUIT A65-24011

QUANTUM ACTIVE PARAMAGNETIC AMPLIFIER IN FORM OF  
SERIES-COUPLED RESONATORS, NOTING BANDWIDTH  
DEPENDENCE ON RESONATOR NUMBER AND DECOUPLING  
INDEPENDENCE A65-24012

HYDROGEN MASER CONSTRUCTION AND OPERATION DESIGN  
PRINCIPLES EMPHASIZING MICROWAVE CAVITY, LOW  
MAGNETIC FIELD, HYDROGEN STORAGE AND MASER TUNING  
TECHNIQUES A65-24309

DIFFRACTION LOSSES, PHASE SHIFTS AND FIELD  
DISTRIBUTION FUNCTIONS FOR TWO LOWEST-ORDER MODES  
ON INTERFEROMETER-TYPE MASER RESONATORS WITH  
CIRCULAR MIRRORS A65-24911

REFLECTION COEFFICIENT OF CAVITY TUBING AS  
EXPLANATION FOR POWER LEVEL OF HELIUM-NEON IR  
FABRY-PEROT INTERFEROMETER A65-30342

MICROWAVE OR LASER RESONATOR WITH FLAT-ROOF MIRROR  
HAS VERY SMALL DIFFRACTION LOSSES AND IS  
INSENSITIVE TO MISALIGNMENT WHEN ROOF ANGLE IS  
VERY SMALL A65-34606

MASER WITH TWO SERIES RESONATORS N65-13904

PARAMETER OF EXCITATION OF MOLECULAR BEAM TYPE  
MASER RESONATOR N65-27253

OSCILLATION OF MASER WITH SINUSOIDAL DISTRIBUTION  
OF RESONATOR FIELD ALONG AXIS OF MOLECULAR MOTION  
A66-11843

TWO-FREQUENCY VOLUME RESONATOR WITH INDEPENDENT  
TUNING WITHIN WIDE FREQUENCY BAND A66-18918

RESONATOR MADE OF MAGNETIC MATERIALS FOR TUNING  
MOLECULAR GENERATOR BY ZEEMAN MODULATION A66-20792

GAIN BANDWIDTH AND STABILITY OF SOLID STATE  
MULTICAVITY MASERS A66-22765

## MATERIAL TESTING

CHEMICAL AND PHYSICAL ASPECTS OF LASERS AND LASER  
MATERIALS WITH REGARD TO TESTING AND SPECIFICATION  
REQUIREMENTS A65-14621

LASER APPLICATION IN CHEMICAL COMPOSITION ANALYSIS  
OF MATERIAL BY SPECTROSCOPIC TECHNIQUE,  
CONSIDERING ORGANIC SUBSTANCE AND PLASMA A65-20004

MATERIAL TESTING FOR GAS LASER OSCILLATOR AND  
SOLID STATE CHELATE LASER - OPTICAL RADARS  
RADC-TR-64-526 N66-12838

## MATERIALS SCIENCE

RAMAN LASER MATERIALS SELECTION, EMPHASIZING  
FREQUENCY SHIFTS AND EXCITATION POWER THRESHOLD  
A66-23477

NASA PROGRAM OF ADVANCED SPACE RESEARCH AND  
TECHNOLOGY - PLANETARY EXPLORATION, ENERGY

## CONVERSION, MATERIALS SCIENCE, AND LASERS

N66-12404

SOLID STATE DEVICES, LASERS, AND MATERIALS SCIENCE  
ABSTRACTS - ANNOTATED BIBLIOGRAPHY  
ESD-TDR-65-318 N66-16745

## MATHEMATICAL MODEL

MODEL DESCRIPTION AND MATHEMATICAL FORMULATION FOR  
SPIKE PULSING PHENOMENON OBSERVED IN OPTICALLY  
PUMPED THREE-LEVEL LASERS A65-27607

GAS LASERS - LEVEL POPULATION DEPENDENCES, LASER  
POWER OUTPUT, METASTABLE DENSITY MEASUREMENTS,  
AND PARAMETER CHANGE EFFECT ON MATHEMATICAL  
MODEL OF LASER SYSTEM S-740 N65-20002

## MATRIX ALGEBRA

OPTIMUM LASER CAVITY STRUCTURES USING MATRIX  
CALCULATIONS BASED ON GEOMETRICAL OPTICS  
APPROXIMATION A65-23846

## MAXWELL EQUATION

MAXWELL EQUATIONS AS MATHEMATICAL MODELS FOR  
SOLUTION OF DIFFRACTION IMAGING THEORY OF  
COHERENT MONOCHROMATIC LIGHT IN MICROSCOPY  
N65-23494

SECOND HARMONIC LIGHT GENERATION, STRESSING  
SATURATION EFFECTS OCCURRING AT HIGH LASER POWER  
LEVELS, SOLVING NONLINEAR COUPLED MAXWELL  
EQUATIONS A66-11443

## MEASURING APPARATUS

PULSE ENERGY AND POWER OF LASERS UNDER CONTINUOUS  
OPERATING CONDITIONS MEASURED, USING CALORIMETERS,  
PHOTOELECTRIC EFFECT OF RADIATION, ETC A66-13205

MEASURING DEVICE FOR PULSED LASER OUTPUT POWER  
USING BOLOMETER, AMPLIFIER AND OSCILLOSCOPE  
A66-13888

LASER PROPERTIES RELEVANT TO MEASUREMENT OF  
PHYSICAL PARAMETERS - MAPPING VIBRATING SURFACE,  
FREQUENCY RESPONSE OF TRANSDUCER, SENSITIVE  
LEVEL, PRESSURE DETERMINATION, AND HOLOGRAMS  
NASA-CR-68235 N66-12860

FRINGE COUNTING MICHELSON INTERFEROMETER USING  
HELIUM-NEON GAS LASER FOR INDUSTRIAL LENGTH  
MEASUREMENT  
SCL-DC-65-92 N66-20322

## MERCURY /METAL/

INTERACTION OF LIGHT PULSE FROM RUBY LASER WITH  
MERCURY SURFACE, OBSERVING MECHANICAL IMPACT  
BELIEVED TO BE RAPID VAPORIZATION PROCESS  
A66-14373

## MERCURY LIGHT

GAS LASER AS LIGHT SOURCE FOR MACH ZEHNDER  
INTERFEROMETER AS COMPARED TO MERCURY VAPOR LAMP  
A65-22949

## MERCURY VAPOR

TIME-VARIATION AND SPONTANEOUS EMISSION FROM HE-  
HG DISCHARGE OF 6149 ANGSTROM LASER TRANSITION  
A65-31451

SODIUM-MERCURY METAL VAPOR LASER  
SP/PH/65-15 N65-33995

## METAL

LASER BEAM INTERACTION WITH METAL FORM OF  
THERMAL, MULTIPLE PHOTON AND ELECTRIC FIELD EFFECT  
A65-27427

IONIZATION UNDER LASER ACTION EXTENDED TO METALS  
AND DIELECTRICS, NOTING INFLUENCE ON THRESHOLDS  
A66-17065

## METAL COMPOUND

PHOTOCHEMICAL BEHAVIOR OF METAL PHTHALOCYANINES  
IN PRODUCING GIANT PULSES FROM RUBY LASER  
N65-23435

## METAL FILM

## SUBJECT INDEX

## METAL FILM

STANDING WAVES IN LASER RESONATORS VERIFIED BY  
PLACING THIN METALLIC FILMS BETWEEN EXTERNAL  
MIRRORS OF PULSED NEODYMIUM LASER A66-22893

## METAL JOINT

LASER WELDING TECHNIQUE EXAMINING JOINT DESIGN,  
WELDABLE MATERIALS AND COSTS A65-32798

LASER WELDING EVALUATED WITH REGARD TO PERFORMANCE  
AND PRODUCTION APPLICATION A66-14692

## METAL OXIDE

GROWTH OF CUBIC PEROVSKITE CRYSTALS AS SYMMETRIC  
HOSTS FOR LASER DOPANT IONS SRCR-65-9 N66-16824

## METAL SURFACE

BACKGROUND GAS PRESSURE EFFECT ON LASER INDUCED  
ELECTRON EMISSION FROM ZINC AND TANTALUM SURFACES  
A65-15838

TIME CORRELATION BETWEEN LASER PULSES AND LASER-  
INDUCED ELECTRON EMISSION FROM METALLIC SURFACES  
A65-34616

ENERGY AND INTENSITY OF IONS EMITTED BY METAL  
TARGET AS FUNCTION OF CHARACTERISTICS OF LASER AND  
NATURE OF METAL A66-15109

REPLICA TECHNIQUES AND ELECTRON AND OPTICAL  
MICROSCOPY TO STUDY LASER IRRADIATED METAL  
SURFACES A66-18393

ELECTRON AND ION EMISSION FROM PULSED RUBY LASER  
ILLUMINATED METALLIC SURFACE INTO VACUUM,  
DETERMINING APPLICATION TO PULSED ION THRUSTOR  
AIAA PAPER 66-230 A66-21453

## METAL VAPOR

SODIUM-MERCURY METAL VAPOR LASER  
SP/PH/65-15 N65-33995

## METAL WORKING

LASER AS THERMAL TOOL IN METAL WORKING PROCESSES  
EXAMINING PHASE TRANSFORMATION A65-20005

PROPERTIES OF LASERS AND APPLICATION TO  
SCIENTIFIC INSTRUMENTATION, COMMUNICATIONS,  
BIOLOGY, PRECISION MEASUREMENTS, METAL WORKING,  
AND MISCELLANEOUS AREAS AFCRL-64-914 N65-16002

## METALLIC PLASMA

DENSITY, TEMPERATURE AND SPEED OF EXPANSION OF  
PLASMA CLOUD PRODUCED BY IMPACT OF RUBY LASER BEAM  
ON ALUMINUM STRIP A65-29558

METALLIC PLASMA TUBE FOR ION LASERS ALLOWS THEM TO  
RUN AT HIGHER CURRENT DENSITIES THAN WITH CERAMIC  
TUBES A66-11373

## METALLURGY

ELECTRON BEAM MELTING HEAT SOURCE IN VACUUM  
METALLURGY, AND RUBY AND NEODYMIUM GLASS LASERS  
FOR INDUSTRY N65-23723

LASER WELDING EVALUATED WITH REGARD TO PERFORMANCE  
AND PRODUCTION APPLICATION A66-14692

## METASTABLE ATOM

TIME RESOLVED SPECTROSCOPY OF MERCURY-HELIUM  
DISCHARGE AND 6150 ANGSTROM LASER OSCILLATION,  
EXAMINING METASTABLE ATOM STATE A65-33518

DEGREE OF EXCITATION OF METASTABLE STATE  
DETERMINED, USING LUMINESCENCE SATURATION  
PHENOMENON, CALCULATING POPULATION OF WORKING  
LEVEL OF LASER SUBSTANCE A66-22027

## METEOROID

METEOROID SIMULATION USING LASERS  
NASA-TM-X-53122 N65-17872

## METEOROLOGICAL PROBE

SENSING OF METEOROLOGICAL VARIABLES BY LASER  
PROBE TECHNIQUES

NASA-CR-71397

N66-21657

## METEOROLOGY

EVALUATION OF MASER-EQUIPPED WEATHER RADAR SET AND  
AREA PRECIPITATION MEASUREMENT INDICATOR -  
METEOROLOGICAL SENSING DEVICE - ELECTRONICS  
CPR-1 N66-14191

MASER EQUIPPED WEATHER RADAR AND PRECIPITATION  
MEASUREMENT INDICATOR CPR-2 N66-15957

## METHANE

ABSORPTION DATA FOR METHANE AND ETHANE, USING HE-  
NE TUNED LASER SPECTROSCOPY A65-20064

HE- NE LASER IR RADIATION EMISSION ATTENUATED BY  
ATMOSPHERIC METHANE A66-23090

POWER AND PATH LENGTH EFFECTS ON STIMULATED RAMAN  
SPECTRA IN METHANE AND HYDROGEN STUDIES USING  
GIANT PULSED LASER N66-26037

## METHYL

GAS LASER OUTPUT AND THRESHOLD IN POPULATION  
INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE  
AND FLUORO IODO METHYLDIYNE A66-16771

## METHYLENE BLUE

LASER POWER DENSITY MEASURED WITH REDUCED  
ABSORPTION OF LIGHT BY METHYLENE BLUE, USING HE-  
NE- CW LASER A65-31455

FLASH PHOTOLYSIS APPARATUS FOR STUDYING SHORT  
LIVED CHEMICAL INTERMEDIATES FROM METHYLENE BLUE  
PSL-102 N66-21833

## METROLOGY

SIMPLE SINGLE MODE HELIUM-NEON LASER WHOSE OUTPUT  
IS SUFFICIENT FOR INTERFEROMETRIC METROLOGY  
A65-22621

## MICA

MICA OPTICAL INTERFERENCE FILTERS FOR SELECTED  
LASER FREQUENCIES AD-466027 N65-28608

## MICHELSON INTERFEROMETER

REFRACTIVE INDEX OF SOLID DETERMINED, USING FAR  
IR MICHELSON INTERFEROMETER ILLUMINATED WITH  
RADIATION FROM CN MASER A65-24683

FRINGE COUNTING MICHELSON INTERFEROMETER USING  
HELIUM-NEON GAS LASER FOR INDUSTRIAL LENGTH  
MEASUREMENT SCL-DC-65-92 N66-20322

## MICROCIRCUIT

TRIMMING MICROCIRCUIT ELEMENTS LIKE EVAPORATED  
THIN-FILM AND SILK-SCREENED CERMET-FILM RESISTORS  
ATTEMPTED WITH CW AND PULSED LASERS A66-14562

## MICROMINIATURIZED ELECTRONIC EQUIPMENT

MICROMINIATURIZED ELECTRONIC LASER RANGE COUNTER  
SOLID STATE DEVICE ECOM-2543 N66-15212

## MICROSCOPY

FLARE IMAGES ROLE IN SELF-DESTRUCTION OF LENS IN  
STRONG LASER BEAM A65-32228

MAXWELL EQUATIONS AS MATHEMATICAL MODELS FOR  
SOLUTION OF DIFFRACTION IMAGING THEORY OF  
COHERENT MONOCHROMATIC LIGHT IN MICROSCOPY  
N65-23494

## MICROWAVE

DEVICES OBTAINING INFORMATION FROM MODULATED LASER  
BEAMS INCLUDING PHOTOEMISSIVE DETECTORS AND SOLID  
STATE PHOTODETECTORS A65-23964

OPTICAL HETERODYNE DETECTION OF MICROWAVE  
MODULATED LIGHT USING TWO SEPARATE LASERS  
EDL-M779 N65-16777

RADIOMETER MASERS, MICROWAVE GENERATION,  
BIOLOGICAL ASPECTS OF MICROWAVES, POLYMERIZATION  
AND OPTIMAL CONTROL

## SUBJECT INDEX

## MINORITY CARRIER

- AD-455792 N65-18884  
MICROWAVE RESEARCH ON ACOUSTIC WAVE AMPLIFICATIONS AND GEOMETRICAL OPTICS, OPTICAL MASERS, ELECTRON-PHONON INTERACTIONS, AND RAMAN SCATTERING FROM BIREFRINGENT CRYSTALS  
ML-1277 N65-20038
- ZERO FIELD X-BAND MASER DESIGN FOR MICROWAVE QUANTUM AMPLIFIERS - MILLIMETER AND SUBMILLIMETER WAVE DEVICES  
REPT.-490F N65-25851
- LINEAR BEAM AND MICROWAVE POWER GENERATION - BEAM-CIRCUIT INTERACTION, BASIC CIRCUITS, BEAM-PLASMA AMPLIFIER, AND LASER-STIMULATED THERMIONIC EMISSION  
RADC-TR-65-22 N65-27099
- MICROWAVE ANTENNA**  
OPTICAL SIMULATION OF MICROWAVE ANTENNAS WITHOUT DIRECT FREQUENCY SCALING, OBTAINING AMPLITUDE DISTRIBUTION OF LASER RADIATION FIELDS  
A65-29418
- MICROWAVE ANTENNA SIMULATION AT OPTICAL FREQUENCY, USING NEON-HELIUM CONTINUOUS GAS LASER  
A66-22539
- MICROWAVE APPARATUS**  
LIFE SUPPORT SYSTEM, FLUID AMPLIFICATION, SPALLING, COMMUNICATIONS SATELLITE, MICROWAVE APPARATUS, HIGH STRENGTH STEEL, TRACERS, LASERS, ATMOSPHERIC TURBULENCE, AND RESONANCE  
AD-611432 N65-22732
- MICROWAVE MODELS OF OPTICAL RESONATORS - LASER OR MICROWAVE RESONATOR WITH FLAT ROOF MIRRORS - OPEN LASER RESONATORS RESEARCH  
AFCL-65-568 N65-34155
- ELECTRONICS METHODS USED IN LASER TECHNOLOGY AND VICE VERSA, EMPHASIZING MICROWAVE PHOTOELECTRONIC DEVICES, SELF-CONSISTENT GAS DISCHARGES AT OPTICAL FREQUENCIES, ETC  
A66-20434
- MICROWAVE ATTENUATION**  
SIGNAL VELOCITY OF MASERS, AND MICROWAVE PHONON ATTENUATION AND PULSED HEAT RADIATION IN SINGLE CRYSTAL SEMICONDUCTORS  
REPT.-8 N65-36734
- MICROWAVE CIRCUIT**  
HIGH SENSITIVITY FAST-RESPONSE LASER DETECTION SYSTEM, DESCRIBING MICROWAVE RESPONSE PHOTOELECTRIC DETECTOR WITH AMPLIFICATION AND MIXING FUNCTIONS  
A66-22046
- MICROWAVE FREQUENCY**  
MICROWAVE AMPLIFICATION ACHIEVED IN SILICON DIODE EXHIBITING MICROPLASMA-FREE AVALANCHE MULTIPLICATION  
A65-19227
- SOLID STATE MICROWAVE MASER ACTION AT 77.4 DEGREES K WITH BROADBANDING TECHNIQUE APPLIED TO INCREASE GAIN-BANDWIDTH PRODUCT, EXAMINING RUBY MATERIAL AND HIGH Q MICROWAVE CAVITIES  
A65-23155
- SYSTEM TRANSLATING FREQUENCY OF GAS LASER OVER RANGE OF SEVERAL GIGACYCLES, ELIMINATING NEED FOR ELECTRO-OPTIC CRYSTALS WITH CUBIC SYMMETRY  
A65-25872
- FEASIBILITY OF SINGLE-MODE MACROSCOPIC OPTICAL WAVEGUIDES AND COMPONENTS OPERATING AT MICROWAVE FREQUENCIES FOR ADVANCED LASER SYSTEMS  
NASA-CR-60527 N65-16252
- MICROWAVE FREQUENCY BEATS IN OFF-AXIS MODES OF RUBY LASERS  
TR-3 N65-35553
- CURRENT-VOLTAGE CHARACTERISTICS OF CW X-BAND GA AS MICROWAVE GUNN GENERATOR  
A66-23029
- MICROWAVE RADIATION**  
MICROWAVE PROBLEMS IN ACOUSTIC WAVE INTERACTIONS, TRANSVERSE WAVE ELECTRON BEAM, OPTICAL SPECTROSCOPY OF LASER MATERIALS, AND NONLINEAR QUANTUM STUDIES  
ML-1243 N65-15605
- GROUND STATE ESR SATURATION EFFECT ON RUBY LASER OUTPUT FREQUENCY AT CRYOGENIC TEMPERATURE  
A66-16753
- SUPERCONDUCTING MAGNET FOR VARIABLE BANDWIDTH TRAVELING WAVE MASERS, NOTING AMPLIFIER BANDWIDTH INCREASE VIA GAIN REDUCTION  
A66-21417
- PICOWAVE RADIATION RESEARCH - ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASERS, SEMICONDUCTOR OSCILLATIONS, RAMAN SCATTERING, FERROMAGNETIC BULK INSTABILITIES, AND NONUNIFORM PLASMAS  
PL-1410 N66-22741
- MICROWAVE RESONANCE**  
MICROWAVE OR LASER RESONATOR WITH FLAT-ROOF MIRROR HAS VERY SMALL DIFFRACTION LOSSES AND IS INSENSITIVE TO MISALIGNMENT WHEN ROOF ANGLE IS VERY SMALL  
A65-34606
- MICROWAVE MODELS OF OPTICAL RESONATORS - LASER OR MICROWAVE RESONATOR WITH FLAT ROOF MIRRORS - OPEN LASER RESONATORS RESEARCH  
AFCL-65-568 N65-34155
- LASER RESEARCH ACTIVITIES IN CHINESE PEOPLES REPUBLIC - FORMATION OF MICROWAVE MASER BY LASER PUMPING, AND FORMATION TIME OF GAS LASER OSCILLATIONS  
JPRS-33323 N66-15048
- FORMATION OF MICROWAVE MASER BY PUMPING OF LOW TEMPERATURE RUBY LASER  
N66-15049
- MICROWAVE TRANSMISSION**  
SYSTEMS ANALYSIS OF LASERS VS MICROWAVES FOR MARS-TO- EARTH COMMUNICATIONS IN 1970  
A65-28248
- SPACE COMMUNICATION REQUIREMENTS USING LASERS AND MICROWAVES IN MANNED MARS FLIGHTS  
AIAA PAPER 65-324 A65-30519
- ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASER, TUNABLE LASER, GEOMETRICAL OPTICS, SEMICONDUCTOR OSCILLATION, AND SOLID STATE PLASMA STUDIES FOR MICROWAVE TRANSMISSION  
ML-1316 N65-27969
- MIE SCATTERING FUNCTION**  
OPTICAL RADAR OBSERVATION OF UPPER ATMOSPHERIC CONSTITUENTS BY LASER BEAMS, EXAMINING NEW METHODS BY RESONANCE SCATTERING OF VARIOUS WAVELENGTHS  
A65-14683
- MILITARY SPACECRAFT**  
CHARACTERISTICS, AND LIMITATIONS OF LASERS FOR APPLICATION IN MILITARY AND SPACE SYSTEMS - CRYSTAL, GLASS, GAS, LIQUID, SEMICONDUCTOR, AND QUASI-LASERS  
LMSC-704217 N65-26625
- MILLIMETER WAVE**  
LOW NOISE KA-BAND TRAVELING WAVE MASER AMPLIFIER FOR WINDOW AT 8 MM WHERE ATMOSPHERIC ATTENUATION IS LOW  
A65-16565
- ZERO FIELD X-BAND MASER DESIGN FOR MICROWAVE QUANTUM AMPLIFIERS - MILLIMETER AND SUBMILLIMETER WAVE DEVICES  
REPT.-490F N65-25851
- MILLIMETER AND SUBMILLIMETER MASER DEVICES - MEASURING TECHNIQUES FOR ZERO FIELD MASER  
REPT.-490G N65-33895
- MILLIMETER AND SUBMILLIMETER MASER DEVICES - IRON-DOPED MASER AMPLIFIER, PUSH-PULL RUTILE MASER, AND X-BAND ZERO FIELD MASERS  
REPT.-490H N66-16210
- MINORITY CARRIER**  
HOMOGENEITY AND DIFFUSION LENGTH OF MINORITY CARRIERS IN SEMICONDUCTORS MEASURED, USING LASER

- BEAM** A65-33809  
 MINORITY CARRIER LIFETIME IN SILICON MEASURED BY CONTACTLESS METHOD, USING LASER INDUCED MODULATION OF IR TRANSMISSION IN SILICON / LIMIRIS/ EFFECT A66-14563
- MIRROR**  
 LASER MIRRORS CONSISTING OF ALTERNATING LEAD-OXIDE AND CRYOLITE FILMS A65-26039  
 MIRROR HOLDER WITH DEFORMABLE HINGES GIVING CONSTANT HINGE LINES AT RIGHT ANGLES FOR GASEOUS AND SOLID STATE LASERS USE A65-28590  
 LOW-LOSS MULTILAYER DIELECTRIC COATINGS BY FILM DEPOSITION FOR LASER MIRROR A65-29525  
 CONDITIONS FOR EXISTANCE OF RADIATING MIRROR LASER ATD-T-65-47 N65-35043  
 LASER MIRRORS CONSISTING OF ALTERNATING LEAD-OXIDE AND CRYOLITE FILMS A66-11820
- MODE SHAPE**  
 RUBY LASER ROD POSITION ALONG INTERFEROMETER AXIS, DETERMINING PRESENCE OF ADJACENT INTERFEROMETER MODES A65-25874  
 LASER MODE DEFORMATION FROM NONUNIFORMITIES IN GAIN SATURATION A65-27328  
 SINGLE MODE LASER EFFICIENCY AT HIGH PUMP LEVELS AS FUNCTION OF PUMPING RATE AND LASER LENGTHS TAKING INTO ACCOUNT MODE SHAPE CHANGES A65-29505  
 HE- NE GAS LASER OSCILLATING IN TWO LINEARLY POLARIZED MODES, COMPARING THEORETICAL AND EXPERIMENTAL MODE INTENSITIES AND BEAT FREQUENCIES A65-32844  
 EFFECT OF NONUNIFORM SPATIAL INTERACTION BETWEEN MODES ON TEMPORAL AND SPATIAL OUTPUT OF RUBY LASER A65-33415  
 RUBY LASER OUTPUT EXHIBITING REGULAR SPIKES A66-10324
- MODULATION**  
 MODULATION OF REFLECTIVITY OF SEMICONDUCTORS ILLUMINATED BY INTENSE LASER BEAMS SSD-TDR-64-253 N65-16566  
 RUBY LASER MODULATION AT ATOMIC LEVEL - FREQUENCY SHIFT MEASUREMENT OF LASER EMISSION UNDER INHOMOGENEOUS MAGNETIC FIELD BY SPECTROSCOPY NASA-CR-57464 N65-19863  
 LASER MODULATION AT ATOMIC LEVEL - YTTRIUM-ALUMINUM GARNET EMISSION AND LASER EMISSION SHIFT WITH HOMOGENEOUS PULSED MAGNETIC FIELD NASA-CR-57823 N65-21308
- MODULATION INDUCING RETRODIRECTIVE OPTICAL SYSTEM**  
 MODULATION INDUCING RETRODIRECTING OPTICAL SYSTEM - DIODE MOUNT FOR GALLIUM ARSENIDE LASERS, AND GENERATION OF ALKALINE LINE BY STIMULATED RAMAN EMISSION NASA-CR-57922 N65-21342
- MODULATION TECHNIQUE**  
 LASER BEAM MODULATING TECHNIQUES AND SCANNING DEVICE TO FORM OPTIMAL VISUAL DISPLAYS RADC-TDR-64-365 N65-20562  
 SELF-MODULATION OF LASER WITH TWO-MODE RESONATOR A66-16775  
 SEMICONDUCTOR LASERS, FM TECHNIQUES AND MULTIPLE-SCATTER PATHS USED TO OVERCOME MODULATION NOISE UNDER VARYING WEATHER CONDITIONS A66-19915
- MODULATOR**  
 LASER MODULATOR USING GALLIUM ARSENIDE AND GALLIUM PHOSPHIDE ELECTRO-OPTIC CRYSTALS NASA-CR-71516 N66-21435
- MOLECULAR ABSORPTION**  
 GAS LASER MOLECULAR ABSORPTION DISCRIMINATION OF CLOSE FREQUENCIES A65-15998
- MOLECULAR BEAM**  
 NORMAL BOLTZMANN DISTRIBUTION INVERSION IN MOLECULAR BEAM TO OBTAIN EXCESS UPPER ENERGY LEVEL POPULATION FOR MASER OSCILLATION A65-15801  
 THERMAL AND SHOT NOISE EFFECTS ON AMPLITUDE AND FREQUENCY OSCILLATIONS OF MOLECULAR BEAM MASER A65-19682  
 BEAM MASER EXCITATION PARAMETER CALCULATIONS INCLUDING COLLISION IN BEAM EFFECTS AND COMPARISON WITH MOLECULAR FORMALDEHYDE A65-24825  
 STEADY STATE OSCILLATIONS OF MOLECULAR BEAM LASER WITH INHOMOGENEOUS SINUSOIDAL FIELD IN RESONATOR A65-36561  
 PARAMETER OF EXCITATION OF MOLECULAR BEAM TYPE MASER RESONATOR N65-27253  
 MASER DEVELOPMENT FROM INVERSIONAL TRANSITIONS IN HEAVY AMMONIA BEAM FTD-MT-64-330 N65-36869  
 PULSE EXCITATION OF VOLUME OF GAS TO COHERENTLY RADIATING STATE APPLIED TO BEAM MASER SPECTROMETER A66-23731  
 AMMONIA MASER - AMMONIA MOLECULAR GENERATOR FTD-TT-65-803/1&2&4 N66-19855
- MOLECULAR COLLISION**  
 VIBRATIONAL, ELECTRONIC AND TRANSLATIONAL ENERGY TRANSFERS OF GAS MOLECULE COLLISIONS, NOTING QUENCHING PROCESS AND FREQUENCY DIFFERENCES EFFECT A65-20068  
 LASER OSCILLATION IN DECAY OF EXCITED MOLECULES FROM CHEMICAL REACTION, NOTING CHANGE IN THREE ELECTRONIC LEVELS IN MOLECULAR SYSTEM A65-20069
- MOLECULAR DISSOCIATION**  
 CHEMICAL PROCESSES PRODUCING SPECTROSCOPICALLY OBSERVABLE POPULATION INVERSIONS IN ATOMIC OR MOLECULAR LASERS A65-20066  
 ATOMIC AND MOLECULAR FLUORESCENCE EXCITED BY PHOTODISSOCIATION, DISCUSSING LINE STRENGTH AND DOPPLER WIDTH A65-20073  
 MOLECULAR SCATTERING OF LIGHT USING RUBY LASER SOURCE CEA-R-2375 N65-32985
- MOLECULAR GAS**  
 POPULATION INVERSION AND OPTICAL MASER OSCILLATIONS IN MOLECULAR GASES N65-23497  
 PUMP TRANSFORMER LASERS - CONVERSION TO SINGLE PLANE-WAVEFRONT BY ABSORPTION AND RE-EMISSION OF MOLECULAR GAS MEDIUM GPL-A-31-1 N65-35530  
 Q-SWITCHING OF CARBON DIOXIDE AND NITROUS OXIDE GAS LASER TRANSITIONS A66-23354
- MOLECULAR OSCILLATION**  
 HIGH SYMMETRY OSCILLATIONS IN CONTINUOUS WATER COOLED SOLID STATE LASERS, SHOWING RELATION TO EXCITATION CONDITIONS A65-14185  
 COHERENTLY DRIVEN MOLECULAR VIBRATIONS AND LIGHT MODULATION - RAMAN SCATTERING BY MASER BEAM NASA-CR-58211 N65-14531  
 C W GAS LASER, MEASURING VIBRATIONAL ROTATIONAL TRANSLATION FREQUENCIES OF CARBON MONOXIDE A66-13984
- MOLECULAR ROTATION**  
 LASER ACTION ON ROTATIONAL TRANSITIONS OF 10-9, 9-8, 8-7, 7-6 AND 6-5 VIBRATIONAL BANDS OF GROUND

# SUBJECT INDEX

# NATURAL FREQUENCY

ELECTRONIC STATE CO A66-18424

VIBRATIONAL AND ROTATIONAL RELAXATIONS IN CARBON DIOXIDE AND NITROUS OXIDE LASER SYSTEMS, USING Q-SWITCHING TECHNIQUES A66-23355

**MOLECULAR SPECTROSCOPY**  
C W GAS LASER, MEASURING VIBRATIONAL ROTATIONAL TRANSLATION FREQUENCIES OF CARBON MONOXIDE A66-13984

**MOLECULAR SPECTRUM**  
SPECTROSCOPIC INVESTIGATION OF LASER EXCITED MOLECULAR SPECTRA FROM POWDERED SOLIDS FOR METEOR AND REENTRY PHYSICS A65-16382

LASER ACTION IN SECOND POSITIVE BAND SYSTEM OF MOLECULAR NITROGEN, OBSERVING SATURATION OF TRANSITION A65-33049

PULSED MOLECULAR NITROGEN LASER THEORY VIA ELECTRON IMPACT EXCITATION OF TRIPLET STATES A65-33050

**MOLECULAR STRUCTURE**  
MOLECULAR ANISOTROPY OF PROPAGATION OF INTENSE LIGHT BEAM, NOTING RAMAN AND BRILLOUIN EFFECTS A66-15106

**MOLYBDATE**  
PREPARATION OF SINGLE CRYSTALS OF DOUBLE MOLYBDATES OF NA AND LA /OR OTHER RARE EARTH ELEMENTS/ DOPED WITH ND, TB OR PR FOR LASER APPLICATION A66-13478

**MOLYBDENUM COMPOUND**  
GADOLINIUM MOLYBDENATE AS FERROELECTRIC HOST IN PULSED LASER, NOTING LIGHT MODULATION AND CRYSTAL DOMAIN A66-23207

**MONKEY**  
CHORIORETINAL LESIONS PRODUCED BY LASER ON MONKEY AND RABBIT A66-80950

CHEMICAL PUMPING OF LASERS - EYE DAMAGE IN MONKEYS FROM LASER IRRADIATION U-3259 N66-13799

**MONOCHROMATIC RADIATION**  
SUPERMODE LASER AS SINGLE-FREQUENCY GENERATION SYSTEM CONSISTING OF FM LASER WITH SYNCHRONOUS PHASE MODULATOR AT OUTPUT A65-29267

LASER PROPERTIES, TECHNIQUES AND USES EMPHASIZING EMISSION MONOCHROMATICITY AND COHERENCE A65-32697

TWO-DIMENSIONAL LASER DEFLECTION USING FOURIER OPTICS A66-10897

**MONT CARLO METHOD**  
MONT CARLO METHOD FOR CALCULATION OF EFFECTIVE FLUORESCENT LIFE TIMES FOR RUBY LASER RODS WITH BREWSTER ANGLE ENDS AND ROUGHENED SIDES UCRL-7765-T/REV. 1/ N65-32343

**MORPHOLOGY**  
LASER RESEARCH IN U.S.S.R., COMBUSTION INSTABILITY IN LIQUID ROCKET AND AIR BREATHING PROPULSION, GAS DYNAMICS AND PROPERTIES AT HIGH TEMPERATURE, AND MORPHOLOGICAL FORMS IN POLYMERS AD-460286 N65-23836

**MOTION EQUATION**  
STABILITY AND SOLUTION OF EQUATIONS OF MOTION FOR TRAVELING WAVE INTERACTIONS IN LASERS A65-19726

GAIN SATURATION OF RUBY MASER BY NEARBY INTERFERING SIGNAL DERIVED FROM MOTION EQUATION OF DENSITY MATRIX A66-19933

**MOTION PICTURE**  
CONTINUOUS WAVE GAS LASER AND HIGH SPEED MOTION PICTURE CAMERA FOR DETECTION OF NEARLY CONTINUOUS SET OF LIGHT SCATTERING PHOTOGRAPHS FROM POLYETHYLENE POLYMER SAMPLE ONR-TR-77 N65-25399

**MULTIMODE RESONATOR**  
MASER APPLICATIONS AS RADIO RECEIVERS, DISCUSSING MULTIRESONATOR ALL-PASS QUANTUM AMPLIFIERS A65-16282

MULTIMODE LASER OSCILLATION RESULTING FROM MODULATION OF DIELECTRIC CONSTANT AND OF LOSS OR GAIN OF LASER MEDIUM A65-17652

MODE LOCKING IN HELIUM-NEON LASER BY MEANS OF SYNCHRONOUS INTRACAVITY ACOUSTIC MODULATION IN COUPLED MULTIMODE CONFOCAL INTERFEROMETERS A65-24276

MASER APPLICATIONS AS RADIO RECEIVERS, DISCUSSING MULTIRESONATOR ALL-PASS QUANTUM AMPLIFIERS A65-25785

LASER BEAM MULTIMODE EFFECTS AS HINDRANCE TO INTERPRETATION OF QUANTITATIVE MEASUREMENTS OF RAMAN GAIN A65-26958

FABRY-PEROT INTERFEROMETER AND CONFOCAL AND SPHERICAL RESONATOR, CALCULATING INTEGRAL EQUATIONS FOR EIGENVALUE AND EIGENFUNCTION OF LOWEST ORDER TW EIGENMODE A66-14277

LASER DEFLECTION AND SCANNING BY MEANS OF MULTIMODE CAVITIES WITH DYNAMIC SPATIAL FILTERS A66-14829

SPIKING BEHAVIOR OF MULTIMODE RUBY LASER IN SPHERICAL RESONATOR, INTERPRETING NEAR-FIELD PATTERNS, FREQUENCY SPECTRUM, ETC A66-21311

TWO-LEVEL ATOM INTERACTION WITH MULTIMODE GAS LASER CAVITY, OBTAINING STATIONARY STATE AND SOLVING UNIQUE EIGENVALUE IN SPECIAL CASES A66-24568

**MUSCLE**  
SOLID STATE LASERS, ACOUSTICS, AND REGENERATION OF MUSCLE TISSUE - TRANSLATIONS OF CHINESE PEOPLES REPUBLIC ARTICLES ON SCIENCE AND TECHNOLOGY JPRS-31817 N65-36115

## N

**N-TYPE SEMICONDUCTOR**  
QUANTUM ELECTRODYNAMICS IN OPTICAL RESONATORS AND MASERS, THERMAL PINCHING, N-TYPE SEMICONDUCTORS, COHERENT LIGHT, TRANSISTOR SWITCHING, POPULATION INVERSION, AND BREAKDOWN AFOSR-65-0248 N65-23491

BROADBAND TRAVELING WAVE MASER TECHNIQUES AND N-TYPE GERMANIUM SEMICONDUCTOR DEVELOPMENT RADC-TR-65-366 N66-15720

**NANOSECOND**  
NANOSECOND HEATING OF AQUEOUS SYSTEMS BY GIANT LASER PULSES AND REDUCTION OF LIGHT ABSORPTION AT HIGH LASER POWER DENSITIES AD-451466 N65-16471

IMAGE FORMING IN ATMOSPHERIC SCATTERING MEDIUM WITH 60 NANOSECOND ILLUMINATING PULSE FROM Q-SWITCHED RUBY LASER AFAL-TR-64-278 N65-25580

**NAPHTHALENE**  
LASER-BEAM SCATTERING BY INDIVIDUALLY INTRODUCED CHARGED POLYSTYRENE SPHERICAL PARTICLES AND DROPLETS OF NAPHTHALENE AND WATER IN COMBINATION A66-17473

**NASA PROGRAM**  
N ASA PROGRAM OF ADVANCED SPACE RESEARCH AND TECHNOLOGY - PLANETARY EXPLORATION, ENERGY CONVERSION, MATERIALS SCIENCE, AND LASERS N66-12404

**NATURAL FREQUENCY**  
NATURAL MODES OF PLANE AND CYLINDRICAL DIELECTRIC RESONATORS IN OPTICAL BAND A65-24810

## NAVIGATION INSTRUMENT

## SUBJECT INDEX

## NAVIGATION INSTRUMENT

NARROW BAND LASER DOPPLER RADAR NAVIGATION  
INSTRUMENT FOR INSTANTANEOUS GROUND SPEED  
TRG-019-I-1 N65-27932

## NAVIGATION SYSTEM

OPTICAL DIFFRACTION VELOCIMETER LASER NAVIGATION  
SYSTEM A65-29275

## NEGATIVE CONDUCTANCE

EFFECT OF LOAD MISMATCH ON LASER OUTPUT,  
DETERMINING NONLINEAR DEPENDENCE OF EQUIVALENT  
NEGATIVE CONDUCTANCE AS FUNCTION OF OSCILLATION  
AMPLITUDE IN LASER RESONATOR CAVITY A66-20435

## NEGATIVE RESISTANCE DEVICE

SWITCHING CHARACTERISTICS OF NEGATIVE RESISTANCE  
DIODE DETERMINATION - INJECTION LASER  
REPT.-7 N65-27203

## NEODYMIUM

QUASI-CONTINUOUS OPERATION OF CALCIUM TUNGSTATE/  
NEODYMIUM ION MASER USING LONG DURATION PUMPING  
PULSES A65-16575

GLASS COMPOSITION EFFECT ON SPECTRAL PROPERTIES OF  
ND-DOPED GLASSES AND SELECTING ONE FOR LASER  
GLASS A65-17635

PHENOMENOLOGICAL TREATMENT OF SATURATION EFFECTS  
IN SOLID STATE LASER AMPLIFIERS A65-18887

CONTINUOUS LASER ACTION IN NEODYMIUM DOPED CALCIUM  
MOLYBDATE AT ROOM TEMPERATURE A65-21627

POWER OUTPUT AND THRESHOLD POWER FOR CONTINUOUS  
WAVE NEODYMIUM-CALCIUM TUNGSTATE LASER IN RANGE OF  
DRY ICE TO ROOM TEMPERATURE A65-22619

STIMULATED EMISSION IN SILICATE GLASS LASER  
CONTAINING NEODYMIUM A65-24189

Q-SWITCHING OF ND LASER USING POLYMETHINE DYE IN  
METHYL ALCOHOL SOLVENT A65-27533

GIANT LASER EMISSION PULSES IN NEODYMIUM ACTIVATED  
GLASS ROD BY VARYING CAVITY Q WITH QUINOLINE  
SOLUTION OF POLYMETHINE DYE A65-27554

RADIAL DEPENDENCE OF ABSORBED ENERGY DISTRIBUTION  
IN CYLINDRICAL ROD OF NEODYMIUM GLASS PUMPED WITH  
XENON SOURCE A65-29792

CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT  
ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH  
NEODYMIUM IONS A65-31703

LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION  
A65-35875

ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION  
IN NEODYMIUM GLASS LASER A65-36826

BREAKDOWN OF ARGON BY NEODYMIUM AND RUBY LASER  
PULSES  
REPT.-1935-1 N65-22072

RUBY AND NEODYMIUM GLASS LASERS FOR INDUSTRY -  
ELECTRONICS N65-23722

ELECTRON BEAM MELTING HEAT SOURCE IN VACUUM  
METALLURGY, AND RUBY AND NEODYMIUM GLASS LASERS  
FOR INDUSTRY N65-23723

SPECTRAL PUMPING EFFICIENCY, SOLARIZATION EFFECT,  
ENERGY OUTPUT, SPECTROSCOPY, GLASS DAMAGE AND  
OPTICAL PATH DISTORTIONS IN NEODYMIUM GLASS  
LASERS  
AD-612964 N65-24195

NEODYMIUM DOPED LASER GLASS COMPARED ON BASIS OF  
FLOURESCENCE CHARACTERISTIC DIFFERENCES  
AD-612459 N65-25901

SUN-POWERED LASER TRANSMITTER DEVELOPMENT - RUBY,  
NEODYMIUM-DOPED GLASS, AND NEODYMIUM-DOPED  
CALCIUM TUNGSTATE LASER MATERIALS

IER-1 N65-29901

PULSED XENON FLASHLAMP AND CONTINUOUS INCANDESCENT  
TUNGSTEN LAMP TRADEOFFS AS NEODYMIUM-YTTRIUM  
ALUMINUM GARNET CRYSTAL LASER PUMPS  
REPT.-3 N65-30242

NEODYMIUM GLASS LASERS AND GENERATION OF HOLE  
BURNING SPECTRAL FLUXES  
AD-464366 N65-31836

GIANT PULSES FROM NEODYMIUM-DOPED GLASS LASER WITH  
PHOTOSENSITIVE LIQUID Q-SWITCH N65-34081

PENTACARBOCYANINE COMPOUND USED TO REDUCE  
MONOPULSE DURATION IN NEODYMIUM LASER A66-10262

LASER OSCILLATION INCREASE IN EFFICIENCY IN  
NEODYMIUM DOPED GLASS PRODUCED THROUGH ENERGY  
TRANSFER A66-10352

INTERNAL BUBBLE FORMATION AND CRACKING IN RODS OF  
Q-SWITCHED RUBY AND ND-GLASS LASERS CAUSED BY  
LASER LIGHT, AND IN CASE OF ND-GLASS RODS, BY  
PLATINUM INCLUSIONS IN GLASS A66-13002

POLARIZATION OF LIGHT FROM GLASS LASER DOPED WITH  
TWO PERCENT POSITIVE TRIVALENT NEODYMIUM MEASURED  
WITH TIME RESOLUTION OF LESS THAN MICROSECOND  
A66-13006

PENTACARBOCYANINE COMPOUND USED TO REDUCE  
MONOPULSE DURATION IN NEODYMIUM LASER A66-13307

ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION  
IN NEODYMIUM GLASS LASER A66-13431

REGULAR PERIODIC SPIKING IN OUTPUT OF PULSED  
NEODYMIUM DOPED BORATE GLASS LASER AT PUMPING  
LEVELS SLIGHTLY ABOVE THRESHOLD A66-16672

LINE NARROWING OF NEODYMIUM GLASS LASER WITH  
REFLECTION A66-17291

Q-SWITCHED OPTICAL MASER SYNCHRONIZATION,  
DISCUSSING EXPERIMENTAL DESIGN, SETUP AND  
PERFORMANCE A66-17297

LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION  
A66-18970

THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-19669

CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT  
ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH  
NEODYMIUM IONS A66-19956

NEODYMIUM DOPED GLASS LASER FOUND TO OSCILLATE IN  
CONVENTIONAL RANDOM PULSATING MANNER UNDER MODE-  
LOCKED CONDITIONS A66-21251

THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-21836

DEPENDENCE OF BEAT FREQUENCY OF NEODYMIUM LASER  
AXIAL MODES ON DISTANCE BETWEEN MIRRORS AND  
NEODYMIUM ROD POSITION WITHIN RESONATOR A66-24881

SOLID STATE OPTICAL MASER RESEARCH - YTTRIUM-  
ALUMINUM-GARNET NEODYMIUM LASER OSCILLATOR AS  
REGENERATIVE NOISE AMPLIFIER - AMPLITUDE  
FLUCTUATIONS  
CR-7 N66-14272

PULSED YTTRIUM-ALUMINUM GARNET NEODYMIUM LASER  
DEVICE - SOLID STATE LASER DEVICE  
CPR-9 N66-14725

STUDIES ON RADIATION PROTECTION FOR MAN, OPTICAL  
MASER OF NEODYMIUM IN TUNGSTATE, CYLINDER WAVE  
PROPAGATION ANALYSIS, AND ELECTROMOTIVE FORCE OF

# SUBJECT INDEX

# NOISE INTENSITY

INDIUM ANTIMONIDE COMPOUND  
JPRS-33152 N66-15042

OPTICAL MASER OF TRIVALENT NEODYMIUM IN TUNGSTATE CRYSTALS N66-15045

RESEARCH IN CHINESE PEOPLES REPUBLIC - SOLAR FLUX, GAS DISCHARGE TUBE, NEODYMIUM LASER, GEOLOGICAL MECHANICS, MICROCRYSTALLINE GLASS, LOCATING OF THUNDER, AND PURIFICATION WITH DISTILLATION METHODS  
JPRS-33759 N66-16806

TRANSMISSION CHARACTERISTICS OF NEODYMIUM LASER N66-16812

GROWTH AND ANNEALING OF OPTICAL MASER CRYSTALS AND SPECTROSCOPIC EVALUATION OF NEODYMIUM-DOPED GLASSES  
PE-TR-8110 N66-17007

LOWER ATMOSPHERE ABSORPTION SPECTRUM STRUCTURE FROM 8512 TO 11600 Å - NEODYMIUM LASER SPECTRUM  
NRL-6352 N66-17604

THERMAL OPTICAL DISTORTION MEASUREMENTS FOR NEODYMIUM DOPED GLASS LASER ROD  
MDE-6236 N66-22419

NEODYMIUM COMPOUND  
NEODYMIUM DOPED CALCIUM TUNGSTATE ROOM TEMPERATURE AMPLIFIER AND C W-LASER OSCILLATOR A65-18873

EFFECT OF LASER OPERATION PARAMETERS USING NEODYMIUM DOPED BORATE GLASS ON THRESHOLD AND OUTPUT ENERGY  
R-1748 N65-25782

SPATIAL DISTRIBUTION OF HOLLOW-CONE SHAPED EMISSION OF MODES WHICH ARE TOTALLY REFLECTED IN NEODYMIUM-GLASS LASERS A66-14291

NEON  
LASER OPERATION MODES ARISING FROM METASTABLE NEON ATOM ANNIHILATION BY HYDROGEN AND OXYGEN MOLECULES A65-18557

HE- NE LASER PROPERTIES AND LASER MECHANISM OF NE ATOMS, NOTING TRANSITION PROCESS AND OSCILLATION DYNAMICS A65-19999

EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE A65-24084

LASER OPERATION MODES ARISING FROM METASTABLE NEON ATOM ANNIHILATION BY HYDROGEN AND OXYGEN MOLECULES A65-27150

EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE A65-34905

RADIATION PROTECTIVE DRUGS, XENON AND HELIUM-XENON LASERS, HELIUM-NEON LASER WITH SILVER AND DIELECTRIC COATINGS, AND TRANSISTOR CIRCUITS  
JPRS-29200 N65-20134

HELIUM-NEON LASER WITH SILVER AND DIELECTRIC COATING N65-20136

SEPARATION OF SINGLE WAVE OSCILLATION MODES OF NEON-HELIUM GAS LASER N65-20782

HELIUM-NEON GAS LASER DIRECT MODULATION N65-22300

RADIATION DIVERGENCE MEASUREMENT IN HELIUM-NEON LASERS WITH CONFOCAL RESONATORS AND SPHERICAL REFLECTORS N65-24550

MULTIBEAM GENERATION OF GASEOUS HELIUM-NEON LASER N65-27252

WAVELENGTH OF 3S2-2P4 TRANSITION OF NEON MEASURED, USING HELIUM-NEON LASER A66-16387

HELIUM-NEON LASER WITH HIGH SPECIFIC POWER FOR

USE WITH OPTICAL TRACKING SYSTEMS AT 6328 Å  
NASA-CR-68589 N66-13349

ENERGY LEVEL RELATIVE POPULATION DENSITIES OF NEON PLASMA USING HELIUM-NEON LASER - LANGMUIR PROBE ADDITIONS FOR MEASUREMENT OF PLASMA ELECTRON TEMPERATURE AND VELOCITY DISTRIBUTIONS  
ARL-65-246 N66-22488

NETWORK SYNTHESIS  
AMPLITUDE NOISE ANALYSIS OF MASER OSCILLATOR, USING VAN DER POL EQUIVALENT CIRCUIT A65-33375

NEUTRON PHYSICS  
ELECTRONICS RESEARCH ON TRAVELING WAVE TUBES, RARE EARTH TARGETS FOR NEUTRON GENERATORS, AND GAS DISCHARGE AND SEMICONDUCTOR INJECTION-TYPE LASERS N65-20166

NITROGEN  
LASER ACTION IN SECOND POSITIVE BAND SYSTEM OF MOLECULAR NITROGEN, OBSERVING SATURATION OF TRANSITION A65-33049

PULSED MOLECULAR NITROGEN LASER THEORY VIA ELECTRON IMPACT EXCITATION OF TRIPLET STATES A65-33050

RAYLEIGH SCATTERING USING LASER LIGHT FOR DETERMINATION OF SCATTERING DENSITY OF ARGON, OXYGEN, AND NITROGEN  
R-135 N65-26127

C W LASER OSCILLATION BETWEEN 11.48 AND 11.55 MICRONS FROM NITROGEN-CARBON DISULFIDE SYSTEM A66-16384

NITROGEN OXIDE  
C W LASER OSCILLATION ON P BRANCH ROTATIONAL TRANSITIONS OF VIBRATION BAND OF NITROUS OXIDE A65-16671

CONTINUOUS GAS LASER BY DIRECT HF EXCITATION OF NITROUS OXIDE AND MIXTURE WITH ARGON IN CAVITY, NOTING PERFORMANCES A65-23273

CONTINUOUS LASER EMISSION DUE TO VIBRATIONAL TRANSITIONS IN CARBON DIOXIDE AND NITROUS OXIDE MIXTURES EXCITED BY HF SOURCE A65-26292

LASER OSCILLATIONS FROM PULSED ELECTRICAL DISCHARGE THROUGH NITROUS OXIDE AT 10.9 MICRON WAVELENGTH N65-20172

NOCTILUCENT CLOUD  
COMBUSTION INSTABILITY, BALL LIGHTNING, SOLAR ACTIVITY, NOCTILUCENT CLOUDS, INTERSTELLAR COMMUNICATIONS, NEODYMIUM LASER, AND HYDROFOILS N65-34075

NOISE  
SOLID STATE OPTICAL MASER RESEARCH - YTTRIUM-ALUMINUM-GARNET NEODYMIUM LASER OSCILLATOR AS REGENERATIVE NOISE AMPLIFIER - AMPLITUDE FLUCTUATIONS GR-7 N66-14272

SIGNAL AND NOISE OUTPUT OF OPTICAL LASER SYSTEMS REPT.-1935-7 N66-15966

NOISE ELIMINATION  
SEMICONDUCTOR LASERS, FM TECHNIQUES AND MULTIPLE-SCATTER PATHS USED TO OVERCOME MODULATION NOISE UNDER VARYING WEATHER CONDITIONS A66-19915

NOISE INTENSITY  
RUBY LASER NOISE RADIATION CONSISTING OF INCREASED LUMINESCENCE AND Laterally DISPERSED GENERATION DETERMINED FROM ENERGY LEVEL POPULATIONS A65-35863

RUBY LASER NOISE RADIATION CONSISTING OF INCREASED LUMINESCENCE AND Laterally DISPERSED GENERATION DETERMINED FROM ENERGY LEVEL POPULATIONS A66-16628

SPONTANEOUS EMISSION NOISE EFFECTS ON COHERENCE



- PROPERTIES OF LASER A66-21550
- QUANTUM MECHANICAL NONLINEAR THEORY OF INTENSITY AND PHASE FLUCTUATIONS OF HOMOGENEOUSLY BROADENED LASER NOISE A66-22466
- NOISE MEASUREMENT**
- AMPLITUDE NOISE MEASUREMENT FOR CAVITY TYPE GASEOUS OPTICAL MASER OSCILLATOR ABOVE AND BELOW THRESHOLD A65-19544
- NOISE BEHAVIOR OF POTENTIAL MINIMUM OF TRAVELING WAVE TUBES AND REDUCTION FACTOR FOR SHOT NOISE DETERMINED, USING LASERS A65-26936
- NOISE TEMPERATURE MEASUREMENT OF RUBY MASER, CONSIDERING GAIN STABILITY AND BANDPASS WIDTH A65-30378
- SPONTANEOUS EMISSION NOISE PROPERTIES OF PAIR OF PULSED RUBY LASER AMPLIFIERS A66-21310
- GC/S NITROGEN-COOLED NONDEGENERATE PARAMETRIC AMPLIFIER, NOTING DESIGN, APPLICATION AND OPERATION CHARACTERISTICS A66-21857
- STATISTICAL ANALYSIS OF NOISE QUALITY OF ATOMIC FREQUENCY STANDARDS INCLUDING MASERS A66-24130
- NOISE SPECTRUM**
- QUANTUM MECHANICS OF SIGNALS AND NOISE IN ATTENUATORS AND MASER AMPLIFIERS, RELATING EXPECTATION VALUES AND THERMAL STATE OF SYSTEM A65-30510
- NOISE OUTPUT AND NOISE FACTOR OF OVERLOADED MASER AMPLIFIERS STUDIED AS FUNCTION OF SMALL-SIGNAL GAIN VS ACTUAL GAIN A65-31032
- AMPLITUDE NOISE ANALYSIS OF MASER OSCILLATOR, USING VAN DER POL EQUIVALENT CIRCUIT A65-33375
- NOISE SUPPRESSOR**
- LASER APPLICATION PROBLEMS IN INTERFEROMETRY, RADAR AND HOLOGRAPHY INCLUDING MECHANICAL STABILITY, NOISE SUPPRESSION, DIRTY LASER BEAM RESTORATION, ETC A66-11454
- NOISE THRESHOLD**
- POWER DENSITY IN NOISE SIDEBANDS OF LASER CAUSED BY EMISSION NOISE IN ACTIVE MEDIUM A65-15321
- NONLINEAR EQUATION**
- QUANTUM MECHANICAL NONLINEAR THEORY OF INTENSITY AND PHASE FLUCTUATIONS OF HOMOGENEOUSLY BROADENED LASER NOISE A66-22466
- NONLINEARITY**
- NONLINEAR OPTICS - LASERS, RAMAN SCATTERING, AND OPTICAL RESONATORS JPRS-29459 N65-21141
- TWO TYPES OF NONLINEAR INTERACTION OF INTENSE LASER BEAM WITH DIELECTRIC MEDIUM - NONLINEAR DC POLARIZATION AND SUBHARMONICS GENERATION AT OPTICAL FREQUENCIES A65-33899
- NONLINEAR EFFECTS IN TRAVELING WAVE LASER AMPLIFIERS AFOSR-65-0999 N66-10779
- LASER-INDUCED NONLINEAR EFFECTS, RAMAN SCATTERING, AND GAS BREAKDOWN - SOVIET LITERATURE REVIEW ATD-P-65-74 N66-12270
- LASER PHYSICS CONFERENCE - ENERGY EXCHANGE IN SOLIDS AND GASES, NONLINEAR EFFECTS, GAS BREAKDOWN, AND REFRACTIVE INDEX VARIATION A66-14573
- NONUNIFORM PLASMA**
- MICROWAVE RADIATION RESEARCH - ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASERS, SEMICONDUCTOR OSCILLATIONS, RAMAN SCATTERING, FERROMAGNETIC BULK INSTABILITIES, AND NONUNIFORM PLASMAS ML-1410 N66-22741
- NUCLEAR ENERGY**
- ENERGY OUTPUT INCREASE OF RUBY LASER CRYSTAL SYSTEMS BY NUCLEAR ENERGY, LASER CRYSTAL GROWTH, AND SURFACE FINISH DEVELOPMENT AD-455571 N65-17595
- NUCLEAR MAGNETIC RESONANCE**
- QUANTUM RF PHYSICS TEXT COVERING MAGNETIC RESONANCE THEORY, ELECTRON PARAMAGNETIC RESONANCE, NUCLEAR MAGNETIC RESONANCES, TWO- AND THREE-LEVEL MASERS, RF GAS SPECTROSCOPY AND AMMONIA OSCILLATOR A66-10954
- NUCLEAR PHYSICS**
- INVESTIGATIONS IN ASTRONOMY, SOLID STATE PHYSICS, OPTICAL MASERS, ATOMIC PHYSICS, AND RADIOACTIVE ATOMS FOR ELECTROMAGNETIC APPLICATIONS NASA-CR-70391 N66-17320
- NUCLEATION**
- EFFECT OF LASER RADIATION ON CHEMICAL ACTIVATION AND VAPOR FOG NUCLEATION MC-64-110-R1 N65-27760
- LASER SIMULATED NUCLEATION IN BUBBLE CHAMBER, COMPARING SENSITIVITY WITH RADIOACTIVELY STIMULATED NUCLEATION A66-21583
- O
- OPACITY**
- OPACITY MEASUREMENT OF XENON FLASH TUBE - OPTICAL MASER NASA-CR-56917 N65-35256
- OPTICAL ABSORPTION**
- FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS SYSTEMS, PRIMARILY LIGHT ABSORPTION AND ATMOSPHERIC SCATTERING A65-15349
- BUILDUP AND DECAY TRANSIENT EFFECTS IN GAS LASERS DUE TO LIGHT ABSORPTION BY INSERTED LIQUID SAMPLES A65-15816
- HEATING AND VAPORIZATION EFFECTS DUE TO HIGH POWER LASER BEAM ABSORPTION AT OPAQUE SURFACES, NOTING ALSO Q-SWITCHED LASERS A65-17663
- ABSORPTION DATA FOR METHANE AND ETHANE, USING HELIUM-TUNED LASER SPECTROSCOPY A65-20064
- FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS SYSTEMS, PRIMARILY LIGHT ABSORPTION AND ATMOSPHERIC SCATTERING A65-32353
- ZEEMAN EFFECT IN PARAMAGNETIC CRYSTALS BY RUBY FOR MICROWAVE MODULATION OF PULSED LASER BY ABSORPTION A65-32746
- TIME CORRELATION BETWEEN LASER PULSES AND LASER-INDUCED ELECTRON EMISSION FROM METALLIC SURFACES A65-34616
- OPTICAL ABSORPTION AND ELECTRON PARAMAGNETIC RESONANCE TECHNIQUES USED TO STUDY IONIZING RADIATION EFFECT ON RUBY LASERS NASA-TN-D-3379 N66-21037
- OPTICAL AMPLIFIER**
- GAIN DELAY CHARACTERISTICS OF FOUR-LEVEL NEODYMIUM-DOPED PULSED GLASS-LASER OSCILLATOR-POWER AMPLIFIER CHAIN A65-16574
- RUBY LASER AMPLIFIER ENERGY INPUT-OUTPUT MATHEMATICAL ANALYSIS AND EXPERIMENTAL VERIFICATION A65-17648
- SINGLE-ATOM COHERENCE EFFECTS IN MEASUREMENT OF SPONTANEOUS EMISSION LINEWIDTHS IN HIGH-GAIN NEON LASER A65-21654
- GASEOUS OPTICAL MASERS CONSIDERING PROBLEM OF DOPPLER BROADENED TRANSITION SUBJECTED TO OPTICAL FREQUENCY FIELD IN STANDING WAVE FORM A65-24005

# SUBJECT INDEX

# OPTICAL GENERATOR

- INTERNAL LOSSES EFFECT ON RADIATION POWER IN LASER  
A65-24058
- PARAMETRIC GAIN ACCOMPANYING PARAMETRIC  
AMPLIFICATION OF LIGHT BEAM BY SECOND HARMONIC  
FREQUENCY OF STIMULATED RADIATION FROM RUBY LASER  
ADP CRYSTALS A65-24280
- OPTICAL AMPLIFICATION OF APPARENT RATE OF  
REFLECTOR ROTATION IN Q-SWITCHING OF LASER  
RESONATOR A65-26946
- OPTICAL GAIN AND LOSSES OF GA AS LASER OF  
EPITAXIAL AND DIFFUSED TYPE A65-33380
- MODEL FOR LASER AMPLIFIER IN WHICH EXCITED  
ELECTRON DENSITY IN HOST LASER MATERIAL IS  
STIMULATED TO PRODUCE OPTICAL ENERGY N65-24343
- RUBY LASER AMPLIFIER AT LIQUID-NITROGEN  
TEMPERATURE TREATED AS THREE-MEDIUM TRANSMISSION  
SYSTEM, NOTING GAIN CHANGE WITH NEGATIVE  
ATTENUATION A66-22867
- OPTICAL BEAM SCANNING**  
LARGE-ANGLE NONMECHANICAL SCANNING OF LIGHT IN ONE  
AND TWO DIMENSIONS THROUGH OPTICAL REFRACTION BY  
TRAVELING ACOUSTIC WAVES A65-21326
- ACQUISITION AND REACQUISITION IN SPACECRAFT-  
SPACECRAFT AND SPACECRAFT-TO- EARTH COMMUNICATIONS  
USING LASER SYSTEMS A65-28249
- OPTICAL BEAM SCANNING AND LASER OUTPUT MODULATION  
BY MEANS OF ULTRASONIC CELL BUILT AROUND FOCUSING  
CYLINDRICAL SECTION TRANSDUCER A65-28419
- LASER SURVEILLANCE USING OPTICAL BEAM SCANNING FOR  
DETECTION OF SPACE SATELLITES AND BALLISTIC  
MISSILES  
RADC-TDR-63-557 N65-22210
- ANGULAR SCANNING OF LASER BEAM FORMING MULTIPLE  
BEAM PHASED ARRAY, MAKING USE OF TIME COHERENCE  
A66-12445
- OPTICAL CORRECTION PROCEDURE**  
ACCURATE LOCATION OF OBJECT IN SPACE AND TIME AND  
CORRECTION OF MOVEMENTS BY USE OF QUANTUM  
ELECTRODYNAMICS A65-25036
- OPTICAL COUPLING**  
BEHAVIOR OF COUPLING-TYPE INTERNAL LASER  
MODULATORS WITH BANDWIDTH COMPARABLE TO MODE  
SPACING A65-16404
- COUPLED OPTICAL RESONATOR SYSTEM CHARACTERISTICS  
USING LASER RESONATORS COUPLED TO EXTERNAL  
RESONATORS N65-23492
- GA AS OPTICALLY COUPLED TRANSISTOR STRUCTURE WITH  
LASING EMITTER A66-12442
- FUSED SILICA OUTPUT COUPLING COMPONENT FOR LASER  
SYSTEM, USING FRUSTRATED TOTAL INTERNAL REFLECTION  
CONFIGURATION A66-17287
- OPTICAL EMISSION**  
SECOND HARMONIC EMISSION AND DIFFRACTION PHENOMENA  
IN KDP CRYSTAL EXCITED BY RUBY LASER BEAM  
A65-29559
- INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY  
AFTER LEAVING LASER AND AFTER FOCUSING WITHIN  
LENS, NOTING OPTIMUM FOCUSING CONDITIONS  
A65-36050
- MODES OF EMISSION-VS-TIME SPECTRUM, OPTICAL  
EMISSION SPECTRUM AND SUPERPOSITION SPECTRUM OF  
SHORT CONFOCAL RUBY LASER IN NEAR FIELD  
A66-14290
- TIME DEPENDENT EMISSION BEHAVIOR OF RUBY LASER  
DISCUSSING RATE EQUATIONS, Q-VALUE, OUTPUT POWER,  
STEADY STATE VALUES, ETC A66-14981
- INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY  
AFTER LEAVING LASER AND AFTER FOCUSING WITHIN
- LENS, NOTING OPTIMUM FOCUSING CONDITIONS  
A66-15853
- TIME DEPENDENT EMISSION BEHAVIOR OF SINGLE AXIAL  
MODE OF DIFFRACTION LIMITED RUBY LASER AT ROOM  
TEMPERATURE A66-20420
- LASER EMISSION - STATE-OF-ART SURVEY  
ISL-T-21/63 N66-13536
- OPTICAL EMISSION SPECTROSCOPY**  
MATERIAL VAPORIZATION BY Q-SPOILED LASER PULSES  
FOR SPECTROSCOPIC ANALYSIS OF VAPOR OPTICAL  
EMISSION AND ABSORPTION PROPERTIES  
AFCRL-64-871 N65-22274
- LASER OSCILLATIONS AND SELF Q SWITCHING,  
DISCUSSING PULSED FLASH-LAMP EXCITATION  
EXPERIMENTS WITH TRIPLY ACTIVATED CONFOCAL BARIUM  
CROWN GLASS ETALON A66-13980
- OPTICAL LASER PUMPS, HIGH POWER CW LASER  
OPERATION BY CATHODOLUMINESCENCE AND SUITABLE  
SELECTION OF PHOSPHORS A66-19546
- OPTICAL EQUIPMENT**  
OPTICAL SWITCH WHICH CUTS OFF LASER PULSE WHEN  
SELECTED BEAM POWER LEVEL IS REACHED  
A65-21626
- CAUSES OF LASER DAMAGE TO OPTICAL COMPONENTS  
PE-TR-7735 N65-14185
- MICROWAVE ANTENNA SIMULATION AT OPTICAL FREQUENCY,  
USING NEON-HELIUM CONTINUOUS GAS LASER  
A66-22539
- LARGE ANGLE DEFLECTION TECHNIQUE FOR PRODUCING  
945-LINE TELEVISION TYPE RASTER SCAN IN DISPLAY  
SYSTEM - ELECTRO-OPTICS, LASERS, AND FIBER  
OPTICS  
UI-912008-1 N66-14858
- OPTICAL DISCRIMINATOR SYSTEM TO IDENTIFY INFRARED  
REFLECTING SURFACES FOR USE IN MASER RESEARCH  
HDL-TM-65-41 N66-17361
- EXPERIMENTAL AND THEORETICAL PROGRAM TO DETERMINE  
FUNDAMENTAL PROPERTIES OF FREQUENCY MODULATION  
AND SUPER-MODE LASERS  
IER-2 N66-21405
- OPTICAL FILTER**  
RUBY LASER TEMPERATURE MEASUREMENT AND FILTERING  
BY DETERMINING SPECTRAL POSITION OF POLARIZATION  
INTERFERENCE BANDS A65-14184
- DETERMINATION OF ATTENUATING FILTERS REQUIRED FOR  
EYE PROTECTION AGAINST LASER RADIATION  
A65-22614
- IMMERSION LIQUIDS FOR HIGH ENERGY RUBY LASERS WITH  
MATCHING REFRACTIVE INDEXES TRANSPARENT AT RUBY  
PUMPING AND LASING WAVELENGTHS A65-22625
- OPTICAL ANALOG COMPUTER TRANSPOSING VARIABLE  
INPUTS INTO SPATIAL DIMENSIONS, USING LASER AS  
LIGHT SOURCE FOR ANTENNA MODELING AND SPECTRUM  
ANALYSIS A65-33770
- MICA OPTICAL INTERFERENCE FILTERS FOR SELECTED  
LASER FREQUENCIES  
AD-466027 N65-28608
- MULTIPLE LIGHT FILTER NARROWING EMISSION BANDS OF  
RUBY LASER WITH MULTIPLEX RESONATOR  
A66-12627
- NEW OPTICS TECHNIQUES INCLUDING INTERFERENCE  
FILTERS, LASERS AND OPTICAL FIBERS  
A66-19118
- OPTICAL GENERATOR**  
STIMULATED COMBINATION LIGHT SCATTERING WITHIN AND  
OUTSIDE RESONATOR CAVITY BASED ON LASER  
DEVELOPMENT A65-16627
- SECOND HARMONIC GENERATION AND MEASUREMENT OF  
NONLINEAR POLARIZATION CONSTANT IN ADP, USING

- FOCUSED LASER BEAM A65-16672
- CONTINUOUS REGIME OPTICAL GENERATOR OUTPUT, THRESHOLD PUMPING LEVEL, INVERSE POPULATION DENSITY AND INDUCED RADIATION ENERGY A65-20326
- MULTIPHOTON ABSORPTION IN LASER GA AS AND RUBY CRYSTAL OF OPTICAL GENERATOR A65-26025
- RADIATION PULSES FROM RUBY OPTICAL QUANTUM GENERATOR DURING SINGLE IGNITION FTD-TT-65-134/162 N65-33409
- MULTIPHOTON ABSORPTION IN LASER GA AS AND RUBY CRYSTAL OF OPTICAL GENERATOR A66-11727
- CD S SINGLE CRYSTAL OPTICAL GENERATOR DURING EXCITATION BY RUBY LASER, DISCUSSING TWO-PHOTON ABSORPTION COEFFICIENT AT 300 DEGREES K FOR RADIATION FLUX DENSITIES A66-13874
- SECOND HARMONIC LIGHT GENERATED ON REFLECTION OF GIANT-PULSE LASER BEAM FROM SURFACE OF SILVER MIRROR A66-16072
- GENERATION IN CADMIUM SULFIDE DURING TWO-PHOTON OPTICAL EXCITATION BY RUBY LASER WITH MODULATED Q-FACTOR A66-19620
- OPTICAL SECOND HARMONIC GENERATION IN FOCUS OF LOWEST TRANSVERSE MODE OF CONTINUOUS WAVE GAUSSIAN GAS LASER BEAM A66-21175
- CONSISTENT THEORY OF NONLINEAR OPTICAL EFFECTS IN BOUNDED LIGHT BEAMS BY EXTENDING PARABOLIC EQUATIONS TO NONLINEAR PROBLEMS A66-24888
- OPTICAL HETERODYNE**
- OPTICAL MIXING OF NITROBENZENE RAMAN RUBY LASER LIGHT IN ADP AND OTHER NONLINEAR DIELECTRIC MEDIA A65-15951
- FREQUENCY SPECTRA MEASUREMENT OF GASEOUS LASER BY PHOTOMIXING TECHNIQUES AND NOISE DISTRIBUTION A65-16405
- MOTION SENSING BY OPTICAL HETERODYNE DOPPLER DETECTION FROM DIFFUSE SURFACES, EXAMINING SPATIAL COHERENCY OF SIGNAL A65-19628
- IMPROVEMENTS NEEDED IN LASER TECHNOLOGY BEFORE OPTICAL COMMUNICATION CAN REPLACE UHF BECAUSE OF LIMITED RELIABILITY OF MICROBEAM OPTICAL LINK A65-23196
- SENSITIVITY OF COHERENT OPTICAL HETERODYNE RECEIVER IN DETECTING LASER RADIATION REFLECTED FROM DIFFUSE SURFACE A65-28005
- LASER DOPPLER FLOWMETER MEASUREMENT TECHNIQUE FOR LOCALIZED FLOW VELOCITIES IN GAS, NOTING RELIABILITY FOR HIGH FLOW VELOCITIES A65-35061
- OPTICAL HETERODYNE DETECTION OF MICROWAVE MODULATED LIGHT USING TWO SEPARATE LASERS EDL-M779 N65-16777
- OPTICAL SUPERHETERODYNE RECEIVER - LASER SYSTEM, DOPPLER FREQUENCY TRACKING, AND OPTICAL TRACKING NASA-CR-63393 N65-26401
- AUTOMATIC FREQUENCY CONTROL OF LASER LOCAL OSCILLATOR FOR HETERODYNE DETECTION OF LASER SIGNAL AND USE OF 2.5 GC FREQUENCY OFFSET TO PERMIT RETRIEVAL OF MICROWAVE DATA A66-14908
- CARBON AND ETHYLENE TETRACHLORIDE ULTRASONIC MODULATORS APPLIED TO IR LASER HETERODYNE EXPERIMENTS ON IN AS PHOTODIODE A66-23353
- PARAMETER DEPENDENCE OF INTERMEDIATE FREQUENCY VOLTAGE INDICATED DURING ESTABLISHMENT OF OPTIMUM CONDITIONS FOR OPTICAL RECEIVERS AND MERIT OF
- SUBCARRIER MIXING A66-23960
- BALANCED MIXER ACTION FOR OPTICAL HETERODYNING, USING MAGIC-T OPTICAL MIXER A66-24153
- OPTICAL RADAR TECHNIQUES - STUDIES OF NEAR HEMISPHERICAL RESONATOR GAS LASER REPT.-1641-6 N66-12795
- OPTICAL IMAGE**
- FLARE IMAGES ROLE IN SELF-DESTRUCTION OF LENS IN STRONG LASER BEAM A65-32228
- TWO-BEAM INTERFEROMETRY BY WAVEFRONT RECONSTRUCTION FROM HOLOGRAM RECORDED WITH COHERENT BACKGROUND SUCCESSIVELY INTERFERE IN SAME LATENT IMAGE A66-23204
- GLASS FIBER LASERS FOR OPTICAL DATA PROCESSING AORC-4502-16-564-42 N66-11060
- OPTICAL INSTRUMENT**
- MIRROR HOLDER WITH DEFORMABLE HINGES GIVING CONSTANT HINGE LINES AT RIGHT ANGLES FOR GASEOUS AND SOLID STATE LASERS USE A65-28590
- OPTICAL DIFFRACTION VELOCIMETER LASER NAVIGATION SYSTEM A65-29275
- COHERENT TRANSFER CHARACTERISTICS OF OPTICAL SYSTEM, HOLOGRAMS AND COMPLEX SPATIAL FILTERS, AND LASER APPLICATIONS C-5210-72-T80-110 N65-21691
- INTENSE LASER RADIATION PROPAGATION - LASER INDUCED GAS BREAKDOWN, PARAMETRIC INTERACTION, COHERENCE, ATMOSPHERIC ABSORPTION, OPTICAL SOURCE AND INSTRUMENTATION AFAL-TR-65-83 N65-25191
- MICROWAVE MODELS OF OPTICAL RESONATORS - LASER OR MICROWAVE RESONATOR WITH FLAT ROOF MIRRORS - OPEN LASER RESONATORS RESEARCH AFCRL-65-568 N65-34155
- THEORETICAL EXPLANATION FOR HIGHLY DIRECTIONAL OFF AXIAL RADIATION FROM SOLID STATE OPTICAL MASERS OF CIRCULAR CROSS SECTION TR-2 N65-34713
- BOOK ON MODERN OPTICS INCLUDING LASER AND COHERENT LIGHT, GEOMETRICAL OPTICS, LENS SYSTEMS, INSTRUMENTS, ETC A66-12623
- MEASUREMENT OF VERTICAL WATER VAPOR PROFILES BY MEANS OF THERMALLY TUNED RUBY LASER OPTICAL RADAR SYSTEM - HUMIDITY MEASUREMENT REPT.-65-6 N66-14852
- OPTICAL MASER**
- OPTICAL MASER APPLIED TO BRILLOUIN SCATTERING SPECTROSCOPY PR-3 N65-13790
- USE OF OPTICAL MASERS IN DISPLAYS AND PRINTERS - DIGITAL ELECTRO-OPTIC LIGHT DEFLECTOR, CEMENTING OF CALCITE CRYSTALS, HIGH SPEED ELECTRONIC SWITCHES, AND BIREFRINGENT CRYSTALS REPT.-6 N65-13857
- CRYSTALS FOR OPTICAL MASER APPLICATION PE-TR-M7920 N65-16442
- OPTICAL MASER APPLIED TO BRILLOUIN SCATTERING SPECTROSCOPY AROD-3922-13 N65-19528
- MICROWAVE RESEARCH ON ACOUSTIC WAVE AMPLIFICATIONS AND GEOMETRICAL OPTICS, OPTICAL MASERS, ELECTRON-PHONON INTERACTIONS, AND RAMAN SCATTERING FROM BIREFRINGENT CRYSTALS PL-1277 N65-20038
- QUANTUM ELECTRODYNAMICS IN OPTICAL RESONATORS AND MASERS, THERMAL PINCHING, N-TYPE SEMICONDUCTORS, COHERENT LIGHT, TRANSISTOR SWITCHING, POPULATION INVERSION, AND BREAKDOWN AFOSR-65-0248 N65-23497

# SUBJECT INDEX

# OPTICAL MODULATION

OPTICAL MASER OUTPUT POWER AFFECTED BY GAS MIXTURE AND PRESSURE, RESONATOR GEOMETRY, AND MIRROR REFLECTIVITY FOR PLASMA RESEARCH

N65-23495

POPULATION INVERSION AND OPTICAL MASER OSCILLATIONS IN MOLECULAR GASES

N65-23497

ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASER, TUNABLE LASER, GEOMETRICAL OPTICS, SEMICONDUCTOR OSCILLATION, AND SOLID STATE PLASMA STUDIES FOR MICROWAVE TRANSMISSION

N65-27969

LINE WIDTH AND INVERSION RATIOS OF IRON-DOPED RUTILE FOR OPTICAL MASER APPLICATIONS

N65-29390

THEORY AND APPLICATION OF MASERS AND LASERS - CESIUM, HELIUM-NEON, AND RUBY MASER OSCILLATOR SYSTEMS

N65-31361

ELECTRONIC DEVICES - DUPLEXERS, PLASMA AMPLIFIERS, CATHODE RAY TUBES, CAPACITORS, THIN FILM TECHNIQUES, AND OPTICAL MASERS

N65-33773

GROWTH OF HIGH OPTICAL QUALITY LANTHANUM-ALUMINUM OXIDE SINGLE CRYSTAL BY CZOCHRALSKI METHOD - DEFENDER PROJECT

N65-34084

THEORETICAL EXPLANATION FOR HIGHLY DIRECTIONAL OFF AXIAL RADIATION FROM SOLID STATE OPTICAL MASERS OF CIRCULAR CROSS SECTION

N65-34713

ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASERS, TUNABLE LASERS, ELECTRON-PROTON INTERACTIONS, SEMICONDUCTORS, GEOMETRIC OPTICS, AND SOLID STATE PLASMA STUDIES

N65-34887

OPACITY MEASUREMENT OF XENON FLASH TUBE - OPTICAL MASER

N65-35256

OPTICAL MASER AS POWER SOURCE FOR NARROW BAND ELECTROMAGNETIC RADIATION THROUGH STIMULATED RAMAN SCATTERING - SOLID STATE PHYSICS

N66-10581

RESONANT CAVITY, OSCILLATION AND RADIATION OUTPUT OF OPTICAL MASERS

N66-11458

SOLID STATE OPTICAL MASER RESEARCH - YTTRIUM-ALUMINUM-GARNET NEODYMIUM LASER OSCILLATOR AS REGENERATIVE NOISE AMPLIFIER - AMPLITUDE FLUCTUATIONS

N66-14272

STUDIES ON RADIATION PROTECTION FOR MAN, OPTICAL MASER OF NEODYMIUM IN TUNGSTATE, CYLINDER WAVE PROPAGATION ANALYSIS, AND ELECTROMOTIVE FORCE OF INDIUM ANTIMONIDE COMPOUND

N66-15042

OPTICAL MASER OF TRIVALENT NEODYMIUM IN TUNGSTATE CRYSTALS

N66-15045

GROWTH AND ANNEALING OF OPTICAL MASER CRYSTALS AND SPECTROSCOPIC EVALUATION OF NEODYMIUM-DOPED GLASSES

N66-17007

INVESTIGATIONS IN ASTRONOMY, SOLID STATE PHYSICS, OPTICAL MASERS, ATOMIC PHYSICS, AND RADIOACTIVE ATOMS FOR ELECTROMAGNETIC APPLICATIONS

N66-17320

SPACE-TO-SPACE AND EARTH-TO-SPACE COMMUNICATION SYSTEMS USING LASER SOURCES

N66-22582

MICROWAVE RADIATION RESEARCH - ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASERS, SEMICONDUCTOR OSCILLATIONS, RAMAN SCATTERING, FERROMAGNETIC

BULK INSTABILITIES, AND NONUNIFORM PLASMAS

N66-22741

## OPTICAL MASER MODULATOR

POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR

A65-36058

OPTICAL CHARACTERISTICS OF PROTOTYPE LASER MODULATORS WITH THIN, FLAT, DISK-SHAPED FABRY-PEROT INTERFEROMETER DESIGN - LASER RADIATION IN COMMUNICATIONS

N65-31681

POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR

A66-15861

## OPTICAL MEASUREMENT

OPTICAL AND LASER THRESHOLD MEASUREMENTS ON 39 FLAME-FUSION RUBIES TO OBTAIN HIGHEST OPTICAL QUALITY LASER RODS

A65-16402

LASER FCG DISDROMETER FOR MEASURING DROPLET SIZE IN FOG

A65-17644

PULSED RUBY LASER OUTPUT MEASUREMENT BY OPTICAL BOLCMETER

A65-18017

LASER APPLICATIONS IN PRECISION AND HIGH SPEED MEASUREMENT AND APPLICATION IN PHOTOGRAPHY, LONG DISTANCE METROLOGY AND PLASMA DIAGNOSTICS

A65-20003

SPIRAL FRINGES IN INTERFERENCE PATTERN OF INTERFEROMETER WITH LASER ILLUMINATION AS INDICATION OF DISCONTINUITY IN WAVE FRONT OR GENERATING SURFACE

A65-33430

HOMOGENEITY AND DIFFUSION LENGTH OF MINORITY CARRIERS IN SEMICONDUCTORS MEASURED, USING LASER BEAM

A65-33809

LASER OPTICAL ALIGNMENT SYSTEM - ALL-WEATHER THEODOLITE WITH TARGET-ATTITUDE MEASURING CAPABILITY

N65-20072

DOPPLER OPTICAL NAVIGATOR TO MEASURE INSTANTANEOUS GROUND SPEED WITH 0.1 FT/SEC ACCURACY FOR ALTITUDES OF 250 TO 5000 FEET - CONTINUOUS WAVE LASER AS TRANSMITTER

N65-28160

INSTRUMENTATION TECHNIQUES FOR NEW TYPE OF GAS DENSITY MEASURING SYSTEM USING LIGHT SCATTERED FROM LASER BEAM AS MEASURED QUANTITY

A66-15794

CROSS SECTION MEASUREMENT FOR ELECTROMAGNETIC BACKSCATTERING OF LASER BEAMS FROM ROUGH ALUMINUM AND MAGNESIUM OXIDE SURFACES

A66-18930

OPTICAL DIFFRACTION VELOCIMETER, USING BACKSCATTERED LASER LIGHT TO MEASURE RELATIVE VELOCITY BETWEEN LIGHT SOURCE AND SURFACE

A66-22958

## OPTICAL METHOD

OPTICAL SIMULATION OF MICROWAVE ANTENNAS WITHOUT DIRECT FREQUENCY SCALING, OBTAINING AMPLITUDE DISTRIBUTION OF LASER RADIATION FIELDS

A65-29418

OPTICAL DATA PROCESSING TECHNIQUES CONSIDERING STORAGE, MANIPULATION, HOLOGRAPHY AND PATTERN RECOGNITION USING MATCHED FILTERS

A66-12997

MICROMACHINING WITH PULSED HELIUM-NEON GAS LASER, NOTING EXPERIMENTAL TECHNIQUES, OPERATION AND APPLICATION

A66-19734

## OPTICAL MODULATION

OPTICAL SECOND HARMONIC GENERATION APPLIED TO HIGH POWER COHERENT SOURCE FREQUENCY TRANSLATION IN COMMUNICATIONS SYSTEMS

A65-19176

RUBY LASER OSCILLATIONS MODULATED BY ULTRASONIC

- VIBRATION A65-19623
- LASER OSCILLATION WHEREIN LASER MODES OSCILLATE WITH APPROXIMATELY FM PHASES THEREBY COMPRISING SIDEBANDS OF FM LIGHT SIGNAL A65-21876
- AUTOMODULATION OF EMISSION FROM SOLID STATE LASER A65-24809
- LASER BEAM DEFLECTION MODULATION OBTAINED BY PASSING CURRENT THROUGH CADMIUM SULFIDE PRISM WITH OHMIC CONTACTS, USED FOR THERMOCOUPLE MEASUREMENTS A65-25890
- MODULATION OF HELIUM-NEON LASER BY LIGHT FROM HELIUM DISCHARGE A65-33006
- ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION IN NEODYMIUM GLASS LASER A65-36826
- LASER MODULATION AT ATOMIC LEVEL - POPULATION INVERSION AND ESTIMATE OF ZEEMAN SPLITTING NASA-CR-60572 N65-16320
- LIGHT MODULATION AND LASER TELECOMMUNICATIONS NASA-TT-F-8762 N65-32178
- OPTICAL PHASE MODULATOR USING FERROELECTRIC BARIUM TITANATE CRYSTAL PLATE A66-10240
- LASER BEAM MODULATION METHODS ASSESSED FOR MAKING USE OF CAPABILITY OF LASER FOR CARRYING MULTITUDE OF SIGNALS SIMULTANEOUSLY A66-11692
- PERIODIC AUTOMODULATION OF RADIATION AND POSSIBILITY OF GENERATING GIANT PULSES IN THREE-LEVEL LASER WITH INHOMOGENEOUSLY EXCITED ACTIVE MEDIUM A66-11842
- FABRY-PEROT INTERFEROMETRIC MODULATOR FOR LASER BEAM, NOTING ERROR OF PRECISE ALIGNMENT OF REFLECTING SURFACES AND GAUSSIAN TYPE OF IMPERFECTIONS A66-12202
- ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION IN NEODYMIUM GLASS LASER A66-13431
- PERIODIC VARIATION OF QUALITY FACTOR OF HE-NE GAS LASER CAVITY BY VIBRATING QUARTZ-MODULATION OF LIGHT BEAM A66-13477
- F M LASER OSCILLATION THEORY DISCUSSING EFFECT OF ARBITRARY ATOMIC LINE SHAPE, SATURATION, MODE PULLING, POWER OUTPUT, SIDEBAND AMPLITUDE, DISTORTION, ETC A66-13954
- SELF-MODULATION OF LASER WITH TWO-MODE RESONATOR A66-16775
- COHERENT INTERFERENCE REJECTION, DISCUSSING NOISE AND MODULATOR-LEAKAGE PICKUP REJECTION IN LASER COMMUNICATIONS EXPERIMENTS A66-17217
- GAS LASER DIRECT MODULATION A66-18355
- INTENSITY FLUCTUATIONS IN OUTPUT OF FOUR-LEVEL CW LASER OSCILLATORS BY LINEARIZED RATE EQUATIONS A66-18434
- MODULATING OUTPUT OF SOLID-STATE LASERS D-920259-12 N66-12814
- OPTICAL PATH**
- INTERFERENCE FRINGE VISIBILITY UP TO 120 M OPTICAL PATH DIFFERENCE, USING HELIUM-NEON LASER SOURCE A65-16766
- FAR FIELD PATTERNS OF OFF-AXIAL MODES IN CYLINDRICAL GLASS NEODYMIUM LASER RODS A65-34807
- SPECTRAL PUMPING EFFICIENCY, SOLARIZATION EFFECT, ENERGY OUTPUT, SPECTROSCOPY, GLASS DAMAGE AND OPTICAL PATH DISTORTIONS IN NEODYMIUM GLASS LASERS AD-612964 N65-24195
- OPTICAL PATH LENGTH CHANGE MEASURED THROUGH LASER RODS WITHIN PUMPING PERIOD BY INTERFEROMETRIC TECHNIQUE A66-11376
- MULTIPLE INTERNAL-REFLECTION FOLDED-PATH RECTANGULAR LASER CONFIGURATION FOR OBTAINING LENGTH OF ACTIVE MEDIA BETWEEN FABRY-PEROT REFLECTORS A66-16652
- LASER RADIATION ABSORBED ALONG SLANT PATHS, SPECTRAL LINE OVERLAPPING AND CENTER LINE SHIFT WITH PRESSURE VARIATION A66-17295
- OPTICAL POLARIZATION**
- POLARIZATION EFFECTS IN RUBY LASER CONSISTING OF RIGHT-ANGLE ROOF-TOPPED ROD WITH C AXIS PERPENDICULAR TO ROOF EDGE, EXTERNAL MULTILAYER DIELECTRIC REFLECTOR AND HELICAL FLASH TUBE A65-29530
- OPTICAL RECTIFICATION IN CRYSTALS USING RUBY LASER BEAM TID-21807 N65-35445
- HIGHER ORDER CALCULATION OF LASER OUTPUT, NOTING APPROXIMATION METHOD FOR LINEWIDTH PARAMETER AND LAMB DIP SHAPE ACCURACY A66-19063
- OPTICAL PROPERTY**
- NONLINEAR OPTICAL EFFECTS IN CRYSTALLINE AND ISOTROPIC MATERIALS DUE TO INDUCED POLARIZATION THIRD ORDER IN ELECTRIC FIELD STRENGTH, USING GIANT PULSED LASER SOURCE A65-16863
- INFRARED SPECTRUM, OPTICAL PROPERTIES, AND FABRICATION OF EIGHT-METER GAS LASER NEL-1242 N65-14446
- OPTICAL PROPERTIES OF CHANGES IN GAS COMPOSITION IN DISCHARGE TUBE FOR HELIUM NEON LASER TR-64-257.10 N65-19952
- LASER SOURCE REFLECTOMETER TO MEASURE REFLECTANCE OF SPECIMENS AT HIGH TEMPERATURE - RELATION OF THERMAL EMISSION TO OTHER OPTICAL PROPERTIES NBS-TN-267 N66-22418
- THERMAL OPTICAL DISTORTION MEASUREMENTS FOR NEODYMIUM DOPED GLASS LASER ROD MDE-6236 N66-22419
- PHONON-PHOTON INTERACTIONS IN OPTICAL SOURCES - THEORETICAL DESCRIPTION OF BRAGG AND RAMAN-NATH SCATTERING CAUSED BY PROPAGATION OF PLANE ACOUSTIC WAVE THROUGH LASER BEAM PATH AFOSR-65-2647 N66-22449
- OPTICAL PUMPING**
- HIGH SYMMETRY OSCILLATIONS IN CONTINUOUS WATER COOLED SOLID STATE LASERS, SHOWING RELATION TO EXCITATION CONDITIONS A65-14185
- MICROWAVE ELECTRON CYCLOTRON RESONANCE PUMPING OF NEON-HELIUM LASER TO RAISE PLASMA ELECTRON TEMPERATURE FOR INCREASE OF OUTPUT A65-15320
- OPTICAL PUMP PULSE SHAPE EFFECT ON POPULATION INVERSION ATTAINED IN RUBY LASER A65-16569
- QUASI-CONTINUOUS OPERATION OF CALCIUM TUNGSTATE/NEODYMIUM ION MASER USING LONG DURATION PUMPING PULSES A65-16575
- MAGNETICALLY UNSHIELDED OPTICALLY PUMPED 87 RB MASER OSCILLATOR A65-16673
- THRESHOLD CONDITIONS FOR CONTINUOUS SELF-SUSTAINED OSCILLATIONS PRODUCED BY REGENERATIVE RUBIDIUM GAS MASER A65-17659
- FABRICATION AND TEST OF CONTINUOUS WAVE LASER ACTION FROM DYSPROSIUM IN CALCIUM FLUORIDE EXCITED BY TUNGSTEN LAMP A65-19184
- WATER COOLED RUBY LASER CONTINUOUSLY OPERATED AT ROOM TEMPERATURE USING ROD IN PUMPING CAVITY A65-19234
- QUASI-CONTINUOUS EMISSION OR REGULAR RELAXATION

# SUBJECT INDEX

# OPTICAL PUMPING

OSCILLATIONS FROM MANY-ELEMENT RUBY LASER  
OPERATING IN VERY FEW AXIAL MODES

A65-19619

HE- NE LASER PROPERTIES AND LASER MECHANISM OF NE  
ATOMS, NOTING TRANSITION PROCESS AND OSCILLATION  
DYNAMICS

A65-19999

LASER ACTION IN RARE EARTH CHELATES, EMPHASIZING  
CHEMISTRY AND SPECTROSCOPIC PROPERTIES OF  
MATERIALS AND PROPERTIES OF LIQUID LASER

A65-20074

OPTICAL PUMPING ENERGY TRANSFER MECHANISM IN RARE  
EARTH CHELATES NOTING POSSIBILITY AS LASER  
MATERIAL

A65-20075

RUBY LASER THRESHOLD PUMPING AND EMISSION ENERGIES  
RELATED TO TRANSMISSION COEFFICIENT, ROD DIAMETER  
AND THRESHOLD LEVEL

A65-20343

EFFECT OF PARTIALLY SHIELDING RUBY LASER ROD FROM  
PUMP LIGHT UPON LONGITUDINAL MODE SPECTRA OF LASER

A65-21657

SELF-SUSTAINED OSCILLATION OBTAINED IN OPTICALLY  
PUMPED RUBIDIUM MASER OPERATING AT TRANSITION  
FREQUENCY OF 6835 MC

A65-21873

LASER FUTURE POSSIBILITIES AND APPLICATION  
CONSIDERING OPTICALLY PUMPED SOLIDS,  
SEMICONDUCTORS AND ANCILLARY EQUIPMENT

A65-21954

QUANTUM THEORY OF OPTICAL PUMPING CYCLE DEVELOPED  
FROM ANALYSIS OF EFFECTS OF LIGHT ON ATOMIC ENERGY  
LEVELS

A65-24003

SOLID STATE LASERS WITH EMPHASIS ON PUMPING  
MECHANISMS, SEMICONDUCTOR DEVICES AND IMPURITY-  
MATRIX SYSTEMS

A65-24007

INSTABILITY IN LASER AMPLIFIER MEDIUM OCCURRING AT  
HIGH PUMPING LEVELS, GIVING TRANSMISSION LINE  
EQUIVALENT CIRCUIT FOR PLANE WAVE PROPAGATION

A65-25888

COHERENT HIGH POWER PULSES FROM OPTICALLY PUMPED  
Y A G- ND LASER BY Q-SWITCHING FROM MIRROR  
ROTATION

A65-26003

PUMPING POWER FORMULA FOR DETERMINING  
CHARACTERISTICS OF CONTINUOUS WAVE AND PULSED  
LASERS

A65-26687

PULSED AND CONTINUOUS WAVE LASER OPERATION OF  
THULIUM ION DOPED ERBIUM OXIDE WHICH PROVIDES  
PUMPING MECHANISM BY MEANS OF ENERGY TRANSFER

A65-26955

HIGH QUANTUM EFFICIENCY IN NARROW BAND TRIVALENT  
RARE EARTH DOPED QUANTUM COUNTER ACHIEVED BY LASER  
PUMPING

A65-27604

MODEL DESCRIPTION AND MATHEMATICAL FORMULATION FOR  
SPIKE PULSING PHENOMENON OBSERVED IN OPTICALLY  
PUMPED THREE-LEVEL LASERS

A65-27607

E-LEVEL POPULATION IN RUBY ROD AS FUNCTION OF PUMP  
ENERGY EMITTED BY FLASH TUBE

A65-28013

TIME DEVELOPMENT OF OUTPUT INTENSITY OF HE- NE  
LASER AFTER QUENCHING BY PUMPING PARTICLES INTO  
LOWER NEON LASER STATE

A65-29075

SINGLE MODE LASER EFFICIENCY AT HIGH PUMP LEVELS  
AS FUNCTION OF PUMPING RATE AND LASER LENGTHS  
TAKING INTO ACCOUNT MODE SHAPE CHANGES

A65-29505

OPTICAL BEAM DIVERGENCE OF 6943 ANGSTROM LIGHT  
CAUSED BY SINGLE PASS THROUGH RUBY LASER AMPLIFIER  
DURING PUMPING

A65-29529

RADIAL DEPENDENCE OF ABSORBED ENERGY DISTRIBUTION  
IN CYLINDRICAL ROD OF NEODYMIUM GLASS PUMPED WITH  
XENON SOURCE

A65-29792

CATHODOLUMINESCENT PHOSPHORS AS LIGHT SOURCE FOR

LASERS, REDUCING HEAT LIMITATIONS AND ELIMINATING  
INTERNAL STRESSES CAUSED BY THERMAL GRADIENTS

A65-30436

REVIEW OF SEMICONDUCTOR LASER DEVELOPMENTS NOTING  
MAGNETIC EFFECTS, MATERIALS FOR IR COHERENT  
RADIATION, OPTICAL LASER, HOLOGRAPHY, ETC

A65-30594

EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER  
WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF  
FORBIDDEN BAND IN GALLIUM ARSENIDE

A65-31307

LASER CONFIGURATIONS, PERFORMANCE FEATURES AND  
LIMITATIONS DISCUSSING HE- NE, ION AND SOLID  
STATE LASERS

A65-31881

QUASI- FERMI LEVEL, FREQUENCY, THRESHOLD PUMPING  
VALUE AND PARTICULAR MODE IN RADIATIVE INTRABAND  
TRANSITION

A65-31884

QUANTUM STATISTICAL PROCEDURE DEVELOPED FOR  
RADIATION FIELD AND APPLIED TO LASER AMPLIFIERS

A65-32707

EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER  
WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF  
FORBIDDEN BAND IN GALLIUM ARSENIDE

A65-33354

CHROMIUM ALIGNMENT IN RUBY BY OPTICALLY PUMPING  
RUBY SAMPLE WITH CIRCULAR POLARIZED RADIATION FROM  
RUBY LASER

A65-33418

THERMAL DISTORTION, EXPANSION AND SCATTERING IN  
RUBY AND GLASS LASER RODS DURING AND AFTER PUMP  
FLASH

A65-35068

U V RADIATION STIMULATED EMISSION IN OPTICALLY  
PUMPED POTASSIUM BROMIDE CRYSTALS USEFUL FOR LASER  
EMISSION WHICH IS CONSISTENT WITH POPULATION  
INVERSION EXCITON SCHEME

A65-35069

GAS MASER PUMP ANALOGOUS TO OPERATION OF HEAT  
ENGINE FOR EXCITING MASER ACTION IN FAR IR,  
DETAILING INTERACTION BETWEEN PURE ROTATIONAL  
STATES OF H CL AND HF

A65-35312

EFFECTS OF RESONATOR LENGTH AND MIRROR  
TRANSPARENCY AND ALIGNMENT UPON DYNAMIC AND STATIC  
CHARACTERISTICS OF RUBY LASER WITH MODULATED  
Q-FACTOR

A65-35786

ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN  
ENERGY ABSORPTION AND POPULATION INVERSION

A65-36055

REFRACTIVE INDEX VARIATION DURING LASER OPERATION  
AND CAST-PLASTIC OPTICAL-PUMP CAVITY EQUIPMENT  
FOR PUMPING AND TEMPERATURE CONTROL DURING  
EXPERIMENT

A65-15753

PINCH METHODS OF GAS DISCHARGE AS LIGHT SOURCE FOR  
OPTICAL PUMPING OF VARIOUS LASER MATERIALS

A65-22742

OPTICAL PUMPING IN DARK RUBY, HARMONIC GENERATION  
IN HYDROGEN CYANIDE, SUBMILLIMETER WAVE  
SPECTROSCOPY, AND MIXING OF LASER LIGHT IN BULK  
PHOTOCONDUCTOR

A65-26426

EFFECT OF OPTICAL PUMPING ON ANOMALOUS DISPERSION  
IN SELECTED RUBY LASERS AND VARIATION OF  
REFRACTIVE INDEX DURING LASER OPERATION

A65-28619

OPTICALLY PUMPED SEMICONDUCTOR LASER IN U.S.S.R.

A65-30208

PULSED XENON FLASHLAMP AND CONTINUOUS INCANDESCENT  
TUNGSTEN LAMP TRADEOFFS AS NEODYMIUM-YTTRIUM  
ALUMINUM GARNET CRYSTAL LASER PUMPS

A65-30242

FREQUENCY STABILIZATION IN VISIBLE SPECTRUM OF  
GAS LASER USED AS OPTICAL PUMP GAIN MODULATOR

- NASA-CR-64359 N65-31013
- KINETIC EQUATION OF LASER OPTIMUM EMISSION,  
DETERMINING PUMPING EFFICIENCY, VALUE OF LOSSES IN  
SPECIAL MODES, ETC A66-11058
- EXCITATION OF RUBY LASERS USING DOUBLE-PUMPED  
HIGH-INTENSITY HELICAL FLASH TUBES, OBTAINING  
TIME-RESOLVED SPECTRA OF ELECTRICAL DISCHARGES AND  
PLASMA TEMPERATURES A66-11446
- OUTPUT POWER AND PULSE DURATION OF RUBY LASER  
A66-12602
- OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING  
POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED  
POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-15352
- ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN  
ENERGY ABSORPTION AND POPULATION INVERSION A66-15858
- PUMPING POWER FORMULA FOR DETERMINING  
CHARACTERISTICS OF CONTINUOUS WAVE AND PULSED  
LASERS A66-15900
- OSCILLATION SPIKES IN QUASI-CONTINUOUS OPERATION  
OF RUBY LASER AT ROOM TEMPERATURE, NOTING  
THRESHOLD PUMPING ENERGY A66-17532
- QUASI-FERMI LEVEL, FREQUENCY, THRESHOLD PUMPING  
VALUE AND PARTICULAR MODE IN RADIATIVE INTRABAND  
TRANSITION A66-18361
- PEAK IRRADIANCE OF OPTICAL PUMP AND TOTAL  
PUMP-ENERGY INCIDENT UPON LASER CRYSTAL  
DETERMINED, ACCOUNTING FOR TEMPERATURE VARIATION  
EFFECTS A66-18487
- LASER DEVELOPMENT, DISCUSSING BASIC THEORY,  
PUMPING METHODS AND LASER TYPES A66-18700
- LASER REGIME WITH GIANT PULSES GENERATED IN  
DYSPROSIUM DOPED CADMIUM FLUORIDE UNDER CONTINUOUS  
PUMPING BY XENON LAMPS, OBTAINING Q FACTOR  
MODULATION BY ROTATING PRISM A66-19376
- INTENSE UV PUMPING EFFECT ON RUBY LASER OUTPUT  
A66-20519
- OPTICAL DOUBLE RESONANCE IN RUBY, DISCUSSING  
ABSORPTION TRANSITIONS FROM LOWEST EXCITED STATE  
OF CHROMIUM ION EFFECTED BY LASER PUMPING A66-20856
- OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING  
POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED  
POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-20893
- PUMP POWER DEPENDENCE OF RUBY LASER STARTING AND  
STOPPING TIME PREDICTED VIA RATE EQUATION ANALYSIS  
A66-21309
- EFFICIENT CONVERSION OF ELECTRICAL ENERGY INTO  
LASER RADIATION, USING COAXIAL OPTICAL PUMP  
A66-23479
- LASER APPLICATION AND TECHNIQUES NOTING  
AMPLIFICATION, MODULATION, INTERFEROMETRY,  
SCATTERING, PLASMA DIAGNOSTICS, NONLINEAR OPTICS,  
ETC A66-23931
- OPTICALLY PUMPED RUBIDIUM 87 MASER OSCILLATOR  
A66-24124
- LASER PUMPING TECHNIQUES - THETA PINCH ENERGY  
TRANSFER EFFICIENCY IN CONVERSION OF ELECTRIC  
ENERGY TO ELECTROMAGNETIC ENERGY  
AFOSR-65-2212 N66-15605
- RUBY LASER RADIATION INTENSITY DISTRIBUTIONS BY  
HIGH SPEED CINEMATOGRAPHY AND TIME RESOLVED  
INTERFEROMETRY FOR PUMPED RADIATION EFFECTS  
N66-16657
- METASTABLE NITROGEN MOLECULES AS ACTIVE MEDIUM  
FOR TRANSFORMER LASER PUMPED BY BATTERY OF ND  
GLASS AUXILIARY LASERS N66-17001
- OPTICAL RADAR  
OPTICAL RADAR OBSERVATION OF UPPER ATMOSPHERIC  
CONSTITUENTS BY LASER BEAMS, EXAMINING NEW METHODS  
BY RESONANCE SCATTERING OF VARIOUS WAVELENGTHS  
A65-14683
- LASER USE IN LONG RANGE MEASUREMENT OF  
TRAJECTORIES  
ONERA TP 166 A65-19046
- MOTION SENSING BY OPTICAL HETERODYNE DOPPLER  
DETECTION FROM DIFFUSE SURFACES, EXAMINING SPATIAL  
COHERENCY OF SIGNAL A65-19628
- LASER RADAR WITH WIDE ANGLE FLOOD-LIGHTING  
LOPSIDED ENERGY BEAM FOR NEAR HORIZON USE WITH  
MINIMUM TERRAIN REFLECTIONS A65-23554
- OPTICAL TRACKING OF SATELLITES EQUIPPED FOR  
GEODETIC TRIANGULATION, USING GROUND LASER BEAMS  
A65-29936
- LIGHT DETECTION AND RANGING / LIDAR/ TECHNIQUE USE  
IN ATMOSPHERIC RESEARCH, PARTICULARLY  
METEOROLOGICAL FACTORS IMPORTANT TO AVIATION AND  
ROCKET OPERATIONS  
AIAA PAPER 65-464 A65-30204
- SOLID STATE LASER AND PHASE SHIFTER DESIGN FOR  
COHERENT OPTICAL RADAR  
AB-1272-0016-2 N65-17148
- RUBY LASER IN OPTICAL RADAR PROBE SYSTEM FOR  
BALLOON SOUNDING OF STRATOSPHERIC AEROSOL  
N65-30205
- ATMOSPHERIC TURBULENCE, POWER FLUCTUATION AND  
RADAR DETECTION IN LASER SYSTEMS DESIGN A66-17294
- LOWER ATMOSPHERIC DENSITY MEASUREMENTS THROUGH  
LIGHT SCATTERING FROM Q-SPOILED RUBY LASER BEAM,  
USING OPTICAL RADAR DETECTOR A66-20398
- MOON SHAPE DETERMINED BY MEASURING DISTANCE FROM  
LUNAR SURFACE POINTS TO LUNAR CENTER OF MASS,  
USING OPTICAL LASER RADAR A66-22964
- RUBY LASER OPTICAL RADAR DETECTION OF UPPER  
ATMOSPHERIC BACKSCATTERING A66-24395
- CLEAR AIR TURBULENCE DETECTION WITH LASER DOPPLER  
OPTICAL RADAR  
AIAA PAPER 66-374 A66-24498
- HIGH POWER LASER AMPLIFIER FOR OPTICAL RADAR  
TRANSMITTER - SPACE SURVEILLANCE SYSTEM  
EOS-5550-Q-1 N66-12355
- OPTICAL RADAR TECHNIQUES - STUDIES OF NEAR  
HEMISPHERICAL RESONATOR GAS LASER  
REPT.-1641-6 N66-12795
- MATERIAL TESTING FOR GAS LASER OSCILLATOR AND  
SOLID STATE CHELATE LASER - OPTICAL RADARS  
RADC-TR-64-526 N66-12838
- SENSING OF METEOROLOGICAL VARIABLES BY LASER  
PROBE TECHNIQUES  
NASA-CR-71397 N66-21657
- OPTICAL RANGEFINDER  
LASER RANGING EXPERIMENTS PERFORMED WITH BEACON  
EXPLORER B A65-21303
- LASER RANGEFINDER DEVICE PROVIDES FAST AND  
ACCURATE RANGE OF NONCOOPERATIVE TARGETS OPERATING  
ON RADAR PRINCIPLE A65-32586
- OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER  
AS AIRCRAFT ALTIMETER TO ELIMINATE SPURIOUS ECHOES  
A65-32588
- LASER RANGING VIA DIGITAL COUNTER COUPLED

## SUBJECT INDEX

## OPTICAL RESONATOR

- PHOTOMULTIPLIER TUBE, NOTING SPECTRAL RESPONSE,  
GAIN TRANSIT TIME DEPENDENCE, OUTPUT COUPLING AND  
EFFECTIVE CATHODE DIAMETER A66-23759
- OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER  
AS TRANSMITTER AND SILICON P-I-N PHOTODIODE AS  
DETECTOR USED AS AIRCRAFT ALTIMETER N66-11665
- RUBY GROWTH PROCESS FOR RANGEFINDER LASER RODS  
QPR-1 N66-19918
- OPTICAL REFLECTIVITY**  
OPTICAL COATING REQUIREMENTS OF LASERS WITH  
RESPECT TO MATERIALS AND MULTILAYER CONFIGURATION  
A65-29528
- SELECTIVE REFLECTION AND DISPERSION PATTERNS NEAR  
RED RUBY LINES, USING RUBY LASER AS LIGHT SOURCE  
A65-33587
- CONICAL EMISSION IN RUBY LASERS WITH EXTERIOR  
MIRRORS A66-14278
- FUSED SILICA OUTPUT COUPLING COMPONENT FOR LASER  
SYSTEM, USING FRUSTRATED TOTAL INTERNAL REFLECTION  
CONFIGURATION A66-17287
- ACCURATE TRACKING OF BEACON- EXPLORER ORBITING  
OPTICAL REFLECTORS, USING PULSED RUBY LASER BEAMS  
A66-19902
- OPTICAL RESONANCE**  
OPTICAL DOUBLE RESONANCE IN RUBY, DISCUSSING  
ABSORPTION TRANSITIONS FROM LOWEST EXCITED STATE  
OF CHROMIUM ION EFFECTED BY LASER PUMPING  
A66-20856
- RUBY LASER RADIATION SPECTRUM AND OPTICAL  
RESONANCE AT ROOM TEMPERATURE  
FTD-TT-65-1312/16264 N66-19914
- OPTICAL RESONATOR**  
GAIN SATURATION, LIGHT POWER LEVEL, DISCHARGE  
CURRENT AND METHOD FOR SPECIFYING OUTPUT POWER  
CHARACTERISTICS OF LASER TUBE A65-15326
- PULSED RUBY LASER ROD CAVITY LOSS MEASUREMENTS  
FROM 77 TO 293 DEGREES K INDICATING ESSENTIALLY  
CONSTANT LOSS A65-16129
- RELATIVE EFFICIENCIES OF SINGLE AND MULTIPLE  
ELLIPTICAL CAVITIES FOR LASER PUMPING PRESENTED IN  
GRAPHICAL FORM A65-16401
- AXIALLY UNIFORM ENERGY DENSITY IN LASER CAVITY  
OBTAINED, USING BIREFRINGENT SAPPHIRE QUARTER WAVE  
PLATES, RUBY ROD AND TWO MIRRORS A65-16407
- MODE IMPURITY OBSERVED IN DIFFRACTION MEASUREMENTS  
EMPLOYING GAS LASER APPARENTLY RESONATING IN  
TEM-00 MODE A65-16571
- STIMULATED BRILLOUIN RADIATION IN OFF-AXIS RUBY  
LASER RESONATOR USING CARBON DISULFIDE CELL,  
EXAMINING OUTPUT SPECTRUM A65-16811
- OPTICAL CAVITY IN WHICH MODES ARE DETERMINED AS  
STATIONARY STATES OF DIFFRACTION-LIMITED OBJECT/  
IMAGE TRANSFORMATION OF CLASSICAL OPTICS  
A65-18013
- CONJUGATE-CONCENTRIC LASER RESONATOR WITH SIMPLE  
IMAGING SYSTEM GEOMETRY DISCUSSING PROPERTIES,  
EIGENVALUE PROBLEM AND FILTERING FUNCTIONS  
A65-18206
- DIFFRACTION LOSSES AND FIELD DISTRIBUTIONS AT  
REFLECTORS OF LOW-LOSS MODES OF SYMMETRIC CONFOCAL  
LASER RESONATOR A65-18315
- HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE  
EXCITATION AND GENERATION KINETICS IN RUBY LASER  
WITH CONCENTRIC CAVITY A65-18460
- CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL  
RUBY CRYSTALS DUE TO HEATING BY EXCITING LIGHT  
A65-18461
- GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM  
INCIDENT ON PLANE PARALLEL GLASS PLATE OF  
RESONATOR A65-18555
- WATER COOLED RUBY LASER CONTINUOUSLY OPERATED AT  
ROOM TEMPERATURE USING ROD IN PUMPING CAVITY  
A65-19234
- HELIUM-NEON LASER RADIATION DISPERSION MEASUREMENT  
IN TRANSITION 3S2-2P4 FOR VARYING MIRROR SPACING  
A65-19693
- MINIMUM VALUE OF TIME DEPENDENT LASER RADIATION  
LOSSES AT WHICH GIANT OSCILLATIONS OCCUR  
A65-19740
- RUBY LASER OUTPUT RADIATION CHANGE DUE TO  
PHthalocyanine SOLUTIONS PLACED IN RESONATOR  
CAVITY A65-21071
- RESONANT MODES OF UNSTABLE OPTICAL RESONATORS AND  
LOSSES A65-21299
- OPTICAL RESONATOR EFFECTS ON POPULATION  
DISTRIBUTION IN HELIUM-NEON GAS LASERS DETERMINED  
FROM SIDE LIGHT MEASUREMENTS A65-21656
- POLARIZED LASER RADIATION WITH RELATION BETWEEN  
INTENSITY AND DIPOLE MOMENT OF ANISOTROPY AND  
PUMPING POWER A65-21805
- LIGHT INTENSITY DISTRIBUTION INSIDE CYLINDRICAL  
REFLECTING CAVITY USING RUBY LASER ROD AND  
ANALYSIS OF INTERDEPENDENCE OF THRESHOLD, FILAMENT  
POSITION AND EFFICIENCY A65-22624
- GLOBAL SPHERICAL CAVITY MODE APPROACH TO MODE  
STRUCTURE OF LASER RESONATOR, USING VECTOR WAVE  
EQUATION A65-22932
- TIME DEPENDENCY OF INTENSITY OF STIMULATED  
EMISSION IN RUBY LASER WITH OPTICAL RESONATOR  
CONTAINING ALUMINUM-COATED OPAQUE SPHERICAL  
MIRRORS A65-23014
- OPTIMUM LASER CAVITY STRUCTURES USING MATRIX  
CALCULATIONS BASED ON GEOMETRICAL OPTICS  
APPROXIMATION A65-23846
- NATURAL MODES OF PLANE AND CYLINDRICAL DIELECTRIC  
RESONATORS IN OPTICAL BAND A65-24810
- HELIUM-NEON LASER MULTIBEAM GENERATION IN GAS  
DISCHARGE TUBE, USING SPHERICAL MIRRORS AND  
TAPERED PLATES A65-24824
- POLARIZED LASER RADIATION WITH RELATION BETWEEN  
INTENSITY AND DIPOLE MOMENT OF ANISOTROPY AND  
PUMPING POWER A65-24857
- STABILITY PARAMETER, SPOT SIZE AND WAVE FRONT  
CURVATURE OF GAUSSIAN BEAM IN RING RESONATOR  
CONTAINING UP TO FOUR UNEQUALLY SPACED SPHERICAL  
MIRRORS A65-24910
- RESONANCE OSCILLATION IN RUBY LASER EMISSION  
STUDIED BY FABRY-PEROT MULTIPLEX ETALON AS  
FUNCTION OF RESONATOR PROPERTIES A65-24976
- ELECTROMAGNETIC FIELD AND SECOND OPTICAL HARMONIC  
GENERATED IN LASER RESONATOR AS TWO INTERDEPENDENT  
PROCESSES A65-25271
- REFLECTION COEFFICIENT OF MIRRORS MEASURED ON  
OPERATING WAVELENGTH OF LASER IN WHICH THEY ARE  
USED A65-25589
- LASER WITH HOLLOW CATHODE DISCHARGE ON NEON-  
HYDROGEN MIXTURE AND CAVITY FORMED BY CYLINDRICAL  
MIRRORS A65-25590
- RUBY LASER ROD POSITION ALONG INTERFEROMETER AXIS,  
DETERMINING PRESENCE OF ADJACENT INTERFEROMETER  
MODES A65-25874
- SINGLE RESONATOR REFLECTION AMPLIFIER ANALYSIS IN  
TERMS OF SCATTERING MATRIX DESCRIPTION OF OPTICAL  
RESONATOR A65-25885



- LASER MIRRORS CONSISTING OF ALTERNATING LEAD-OXIDE AND CRYOLITE FILMS A65-26039
- PHYSICAL PRINCIPLES OF LASERS AND APPLICATION IN STUDYING RADIATION AND MATTER INTERACTION A65-26933
- GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM INCIDENT ON PLANE PARALLEL GLASS PLATE OF RESONATOR A65-27148
- RAMAN DIFFUSION OF LIQUIDS PLACED OUTSIDE OPTICAL CAVITY AND EXCITED BY RUBY LASER A65-27944
- HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE EXCITATION AND GENERATION KINETICS IN RUBY LASER WITH CONCENTRIC CAVITY A65-28089
- CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL RUBY CRYSTALS DUE TO HEATING BY EXCITING LIGHT A65-28090
- ELECTRIC CIRCUIT ANALOG OPTIMUM DESIGN OF MODE-SELECTIVE MULTIREFLECTOR FABRY- PEROT LASER RESONATORS A65-30344
- RUBY LASER OUTPUT RADIATION CHANGE DUE TO PHALOCYANINE SOLUTIONS PLACED IN RESONATOR CAVITY A65-31236
- LASER OPERATION PRINCIPLES AND OSCILLATING ELEMENT OF LASER RESONATOR A65-31880
- MICROWAVE OR LASER RESONATOR WITH FLAT-ROOF MIRROR HAS VERY SMALL DIFFRACTION LOSSES AND IS INSENSITIVE TO MISALIGNMENT WHEN ROOF ANGLE IS VERY SMALL A65-34606
- SYNCHRONIZED GENERATION OF RADIATION BY ALL SEMICONDUCTOR ELEMENTS OF LASER SYSTEM WITH RADIATIVE MIRRORS CAUSED BY DIFFRACTION OF ELECTROMAGNETIC FIELD A65-35279
- DESIGN AND CONSTRUCTION OF STABLE SINGLE FREQUENCY RF EXCITED HE- NE LASER AT 6328 ANGSTROMS A65-35358
- LASER EMISSION WITH VARIABLE RESONATOR LOSSES, CONSIDERING RELATIVELY LOW INITIAL OVERPOPULATION A65-35784
- TRUNCATED EQUATIONS DESCRIBING COHERENT RADIATION OF EXCITED CHROMIUM IONS IN RUBY SITUATED IN TRAVELING WAVE RESONATOR A65-35919
- LASER MODE OPERATION IN PRESENCE OF RADIATION ABSORBING IMPURITY ANALYZED BY EXTENDED THOMSON TYPE SYSTEM A65-35930
- CIRCULAR DIELECTRIC RESONATOR UNDER CRITICAL OPERATING CONDITIONS IN ANALYSIS OF PERFORMANCE AND ENERGY LOSS A65-36011
- OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF SOLID STATE LASER AND COMPENSATION VIA LENS IN RESONATOR A65-36051
- THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE LOSSES IN FABRY- PEROT RESONATORS DUE TO MIRROR MISALIGNMENT A65-36053
- STEADY STATE OSCILLATIONS OF MOLECULAR BEAM LASER WITH INHOMOGENEOUS SINUSOIDAL FIELD IN RESONATOR A65-36561
- NONLINEAR OPTICS - LASERS, RAMAN SCATTERING, AND OPTICAL RESONATORS JPRS-29459 N65-21141
- QUANTUM ELECTRODYNAMICS IN OPTICAL RESONATORS AND MASERS, THERMAL PINCHING, N-TYPE SEMICONDUCTORS, COHERENT LIGHT, TRANSISTOR SWITCHING, POPULATION INVERSION, AND BREAKDOWN AFOSR-65-0248 N65-23491
- COUPLED OPTICAL RESONATOR SYSTEM CHARACTERISTICS USING LASER RESONATORS COUPLED TO EXTERNAL RESONATORS N65-23492
- UNSTABLE OPTICAL RESONATORS FOR RUBY LASER APPLICATIONS ML-1227 N65-33916
- MICROWAVE MODELS OF OPTICAL RESONATORS - LASER OR MICROWAVE RESONATOR WITH FLAT ROOF MIRRORS - OPEN LASER RESONATORS RESEARCH AFCRL-65-568 N65-34155
- SELF-LOCKED GAS LASER MODE DEPENDENCE ON CAVITY LENGTH AND POSITION OF LASER MEDIUM IN CAVITY A66-10347
- PHASE RELATIONS OF LONGITUDINAL MODES IN GAS LASER WITH ANNULAR RESONATOR A66-10726
- REFLECTION COEFFICIENT OF MIRRORS MEASURED ON OPERATING WAVELENGTH OF LASER IN WHICH THEY ARE USED A66-11420
- LASER WITH HOLLOW CATHODE DISCHARGE ON NEON-HYDROGEN MIXTURE AND CAVITY FORMED BY CYLINDRICAL MIRRORS A66-11421
- TRAVELING WAVE OSCILLATIONS IN RUBY LASER RESONATOR USING PASSIVE OPTICAL ISOLATOR, ELIMINATING FARADAY ROTATOR AND ATTENDANT MAGNETIC FIELD A66-11448
- LASER MIRRORS CONSISTING OF ALTERNATING LEAD-OXIDE AND CRYOLITE FILMS A66-11820
- CURRENT DISCHARGE OF HELIUM NEON LASER ON LASER ACTION A66-12439
- MULTIPLE LIGHT FILTER NARROWING EMISSION BANDS OF RUBY LASER WITH MULTIPLEX RESONATOR A66-12627
- MULTIREFLECTOR FABRY- PEROT LASER RESONATORS, DISCUSSING SUPPRESSION EFFECT AGAINST UNWANTED MODES A66-13325
- OPTICAL RESONATOR USING CYLINDRICAL MIRROR WITH VARIABLE RADIUS OF CURVATURE A66-13890
- FABRY- PEROT INTERFEROMETER AND CONFOCAL AND SPHERICAL RESONATOR, CALCULATING INTEGRAL EQUATIONS FOR EIGENVALUE AND EIGENFUNCTION OF LOWEST ORDER TW EIGENMODE A66-14277
- TRAVELING WAVE OSCILLATIONS OF ION RING LASER IN MIRROR-RING RESONATOR A66-14903
- OUTPUT SPECTRA OF ARGON ION LASER IN RING RESONATOR AND TWO MIRROR RESONATORS A66-14904
- MICROWAVE MODELS USED TO MEASURE FREQUENCY AND QUALITY FACTORS OF FABRY- PEROT RESONATOR WITH PLANE SQUARE MIRRORS OPERATING IN X-BAND A66-14909
- MODULATION OF LASER LIGHT WITH COMPOSITE FABRY- PEROT RESONATOR, USING MORE THAN THREE MULTIPLE REFLECTING PLATES A66-15836
- OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF SOLID STATE LASER AND COMPENSATION VIA LENS IN RESONATOR A66-15854
- THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE LOSSES IN FABRY- PEROT RESONATORS DUE TO MIRROR MISALIGNMENT A66-15856
- DISPERSION RESONATOR PERFORMANCE IN RUBY LASER, SHOWING GENERATION OF  $R_{SUB 1}$  AND  $R_{SUB 2}$  LINES A66-16346
- MODE COMPETITION AND COUPLING IN Q-SWITCHED RUBY LASER A66-16383
- OPTICAL DESIGN OF ELLIPTICAL CAVITIES AND COMPARISON OF ENERGY TRANSFERS FROM LIGHT SOURCE TO RUBY LASER WITH CYLINDRICAL CAVITIES A66-16647
- SOLID STATE LASER OUTPUT EXHIBITING REGULAR AND IRREGULAR SPIKES ANALYZED THROUGH RELAXATION

# SUBJECT INDEX

# OPTICAL TRANSITION

- OSCILLATIONS AND CLASSICAL PHYSICS
  - A66-20568
- EIGENVALUES OF INTEGRAL EQUATIONS IN LASER  
RESONANT CAVITIES
  - A66-21343
- THEORETICAL OPTICAL RESONATOR FOR LASER WITH RARE  
EARTH LIQUID SOLUTIONS AS ACTIVE COMPONENTS
  - A66-21970
- MULTIPLEX LIGHT FILTER FOR EXCITATION OF RUBY  
LASER
  - A66-22032
- DISPERSION RESONATOR PERFORMANCE IN RUBY LASER,  
SHOWING GENERATION OF R SUB 1 AND R SUB 2 LINES
  - A66-22345
- STANDING WAVES IN LASER RESONATORS VERIFIED BY  
PLACING THIN METALLIC FILMS BETWEEN EXTERNAL  
MIRRORS OF PULSED NEODYMIUM LASER
  - A66-22893
- MODE SUPPRESSION TECHNIQUES FOR GAS LASER SINGLE  
AXIAL MODE OPERATION FOR LARGE MIRROR SEPARATIONS
  - A66-23093
- LASER ACTION ON ROTATIONAL LINE IN CARBON DIOXIDE  
AND NITROUS OXIDE VIBRATIONAL SPECTRA IN BOTH P  
AND R BRANCHES UP TO J VALUES OF OVER 50
  - A66-23357
- EQUATIONS OF MOTION GOVERNING INTERACTION OF  
OPTICAL MODES IN PRESENCE OF TIME-VARYING  
PARAMETERS
  - A66-24559
- TWO-LEVEL ATOM INTERACTION WITH MULTIMODE GAS LASER  
CAVITY, OBTAINING STATIONARY STATE AND SOLVING  
UNIQUE EIGENVALUE IN SPECIAL CASES
  - A66-24568
- DEPENDENCE OF BEAT FREQUENCY OF NEODYMIUM LASER  
AXIAL MODES ON DISTANCE BETWEEN MIRRORS AND  
NEODYMIUM ROD POSITION WITHIN RESONATOR
  - A66-24881
- MACROSCOPIC WAVEGUIDE AND WAVEGUIDE COMPONENTS FOR  
OPTICAL SYSTEMS - LASERS
  - NASA-CR-332
  - N66-16086
- OPTICAL SENSOR
  - ROCKET MISSILE ATTITUDE SENSING DURING EARLY  
LAUNCH PHASE USING POLARIZED LASER BEAMS  
TRANSMITTED FROM GROUND STATION
    - A65-23619
- OPTICAL SIGNAL
  - LIGHT WAVE FREQUENCY CONVERSION BY LASER CRYSTAL,  
EXAMINING RESULTANT HARMONICS
    - A65-15508
  - SEMICONDUCTOR LASER DIGITAL DEVICES FOR GENERAL  
PURPOSE LOGIC CIRCUITS BASED ON NONLINEAR  
INTERACTION OF INTENSE OPTICAL SIGNALS
    - A65-19342
  - PARAMETRIC CONVERSION OF OPTICAL FREQUENCIES IN  
CRYSTAL ILLUMINATED BY LASERS
    - A65-28626
  - LASER LIGHT REDISTRIBUTION IN ILLUMINATING OPTICAL  
SIGNAL PROCESSING SYSTEMS NOTING APODIZATION,  
SPATIAL MODES AND ASPHERIC ELEMENTS
    - A66-14830
  - OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING  
POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED  
POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL
    - A66-15352
  - OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING  
POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED  
POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL
    - A66-20893
  - TEXT ON HIGH SPEED OPTICAL PULSE TECHNOLOGY,  
LASERS AND MEASURING TECHNIQUES, EMPHASIZING  
CAPACITOR DISCHARGE APPLICATION
    - A66-22063
- OPTICAL SPECTRUM
  - QUANTUM THEORETICAL ANALYSIS OF LASER BEAM
- FLUCTUATIONS AND OF LIGHT BEAT EXPERIMENTS WITH  
TWO LASERS
  - A65-25059
- OPTICAL TRACKING
  - SATELLITE-BORNE LASER ELECTRO-OPTICAL NAVIGATION  
SYSTEM, ANALYZING ANGULAR TRACKER AND CORNER-  
REFLECTOR SENSOR
    - A65-29242
  - LASER IN SPACE APPLICATION, DISCUSSING ELECTRO-  
OPTICAL DEVICES
    - A65-31883
  - LASER BEACON FOR DAYLIGHT OPTICAL TRACKING -  
COMPONENTS DESCRIPTION, SIGNAL TO NOISE RATIO,  
AND SIGNAL SENSITIVITY
    - NASA-CR-62616
    - N65-23285
  - OPTICAL SUPERHETEROCYNE RECEIVER - LASER SYSTEM,  
DOPPLER FREQUENCY TRACKING, AND OPTICAL  
TRACKING
    - NASA-CR-63393
    - N65-26401
  - RANGE OF LASER TELEMETRIC DEVICE WITH REFLECTOR  
ON TRACKING OBJECT
    - ONERA-TP-166/1964/
    - N65-28497
  - SYSTEM FOR OPTICAL ACQUISITION AND TRACKING, AND  
LASER BEAM DEFLECTOR DEVICES - ELECTRO-OPTICAL  
TECHNIQUES FOR CONTROLLING DIRECTION OF LASER  
BEAM FLOW
    - NASA-CR-64222
    - N65-30541
  - BALLOON-BORNE XENON LIGHT OPTICAL BEACON FOR  
LASER AND OPTICAL TRACKING, AND MISSILE-BORNE  
XENON OPTICAL BEACON FOR OPTICAL TRACKING
    - B-3068
    - N65-31897
  - HELIUM-NEON LASER WITH HIGH SPECIFIC POWER FOR  
USE WITH OPTICAL TRACKING SYSTEMS AT 6328 Å
    - NASA-CR-68589
    - N66-13349
  - HIGH ENERGY LASER SYSTEM FOR LARGES GEODETIC  
SATELLITE OPTICAL TRACKING
    - B-3011
    - N66-14591
  - PIEZOELECTRICALLY POWERED LASER BEAM WAVEGUIDE FOR  
ELECTRO-OPTICAL ACQUISITION AND TRACKING
    - NASA-CR-68895
    - N66-17291
  - LASER BEAM TRACKING OF BEACON EXPLORER  
SATELLITES
    - NASA-TM-X-56631
    - N66-22191
  - RESEARCH REVIEW OF OPTICAL TRACKING, GUIDANCE, AND  
COMMUNICATION STUDIES AT MSFC
    - N66-23457
  - OPTICAL RENDEZVOUS GUIDANCE SYSTEM AND GROUND  
BASED OPTICAL TRACKING SYSTEM DEVELOPMENT
    - N66-23458
- OPTICAL TRANSITION
  - CONTINUOUS LASER EMISSION DUE TO VIBRATIONAL  
TRANSITIONS IN CARBON DIOXIDE AND NITROUS OXIDE  
MIXTURES EXCITED BY HF SOURCE
    - A65-26292
  - KINETIC EQUATION THEORY APPLIED TO STEADY STATE  
LASER RADIATION DUE TO BAND-BAND TRANSITION IN  
SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS
    - A65-26694
  - LASER OSCILLATION IN GASEOUS IONS, TABULATION OF  
WAVELENGTHS, CLASSIFICATIONS AND REFERENCES FOR  
230 ION LASER TRANSITIONS
    - A65-30343
  - KINETIC EQUATION THEORY APPLIED TO STEADY STATE  
LASER RADIATION DUE TO BAND-BAND TRANSITION IN  
SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS
    - A65-32952
  - LASER ACTION ON P- AND R-BRANCH TRANSITIONS OF  
CARBON DIOXIDE VIBRATIONAL SPECTRUM BAND PRODUCED  
BY PULSED DISCHARGE ADMIXTURE OF VARIOUS GASES
    - A65-33058
  - ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION  
INVERSION IN LEVELS OF OPTICAL TRANSITION
    - A66-10448
  - ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION  
INVERSION IN LEVELS OF OPTICAL TRANSITION

## OPTICS

## SUBJECT INDEX

- A66-13311  
SIMULTANEOUS ACTION OF RF PERTURBATION BETWEEN ZEEMAN SUBLEVELS OF ATOMIC TRANSITION WHICH IS ALSO PRODUCING LASER OSCILLATION  
A66-21177  
Q-SWITCHING OF CARBON DIOXIDE AND NITROUS OXIDE GAS LASER TRANSITIONS  
A66-23354
- OPTICS**  
INTERFEROMETER EXPERIMENT OF HELIUM-NEON LASER SHOWS ITS RADIATION OBEYS LAWS OF CLASSICAL OPTICS  
A65-19994  
LASER APPLICATION IN MEDICINE, MANUFACTURING, SPECTROSCOPY, OPTICS AND COMMUNICATIONS  
A65-31882  
MONOGRAPH ON THEORY OF COHERENCE IN OPTICS INCLUDING CONCEPT OF DEGREE IN COHERENCE, COHERENCE IN QUASI-MONOCHROMATIC LIGHT AND IN DIFFRACTION PHENOMENA  
A65-33897  
NONLINEAR OPTICS - LASERS, RAMAN SCATTERING, AND OPTICAL RESONATORS  
JPRS-29459  
N65-21141  
OPTICAL COHERENCE AND NONLINEAR INTERACTION OF LIGHT WAVES IN DIELECTRICS  
REPT.-1579-17  
N65-21553  
OPACITY MEASUREMENT OF XENON FLASH TUBE - OPTICAL MASER  
NASA-CR-56917  
N65-35256  
BOOK ON MODERN OPTICS INCLUDING LASER AND COHERENT LIGHT, GEOMETRICAL OPTICS, LENS SYSTEMS, INSTRUMENTS, ETC  
A66-12623  
NEW OPTICS TECHNIQUES INCLUDING INTERFERENCE FILTERS, LASERS AND OPTICAL FIBERS  
A66-19118  
SIGNAL AND NOISE OUTPUT OF OPTICAL LASER SYSTEMS  
REPT.-1935-7  
N66-15966  
OPTICAL TECHNOLOGY, LASER, AND MICROELECTRONICS RESEARCH REVIEW AT MARSHALL SPACE FLIGHT CENTER  
NASA-TM-X-53364  
N66-23456
- OPTICAL CONTROL**  
RADIOMETER MASERS, MICROWAVE GENERATION, BIOLOGICAL ASPECTS OF MICROWAVES, POLYMERIZATION AND OPTICAL CONTROL  
AD-455792  
N65-18884
- ORGANIC COMPOUND**  
ORGANIC CATIONS EFFECT ON LASER THRESHOLD OF SOLUTIONS OF TETRAKIS FORM OF EUROPIUM BENZOYLTRIFLUOROACETONATE  
A66-18418
- ORGANIC FLUORINE COMPOUND**  
REFRACTIVE INDEX OF SOLID DETERMINED, USING FAR IR MICHELSON INTERFEROMETER ILLUMINATED WITH RADIATION FROM CN MASER  
A65-24683
- ORGANIC LASER**  
STIMULATED EMISSION AT ROOM TEMPERATURE IN EUROPIUM CHELATE SOLUTION  
A65-21625  
ORGANIC LASER CONFERENCE  
TR-64-052.6  
N65-15502  
ORGANIC LASER DEVELOPMENT  
N65-15503  
STIMULATED EMISSION IN FLUORESCENT ORGANIC MOLECULES  
N65-15504  
ENERGY TRANSFER IN RARE EARTH CHELATES - IMPLICATIONS FOR ORGANIC LASER DESIGN  
N65-15505  
RARE EARTH CHELATE LASERS  
N65-15508  
PRODUCTION OF STIMULATED EMISSION IN BLUE-GREEN REGION IN ORGANIC DOPANT AND HOST SYSTEM - AROMATIC ORGANIC LASER DEVELOPMENT
- AD-613295  
N65-25734  
FLUORESCENT ORGANIC LASER DEVELOPMENT - THETA PINCH ARGON LAMP MEASUREMENTS  
GR-7  
N65-25966  
PERIPHERAL MODES IN CHELATE LASER, NOTING LUMINESCENCE EMITTED BY AXIS OF CYLINDRICAL CELL AND LATERAL FACE  
A66-15171
- ORGANISM**  
RUBY LASER FOR STUDY OF LASER RADIATION EFFECTS ON BIOLOGICAL ORGANISMS  
GR-3885  
N66-10583
- OSCILLATION**  
LASER OSCILLATIONS FROM PULSED ELECTRICAL DISCHARGE THROUGH NITROUS OXIDE AT 10.9 MICRON WAVELENGTH  
N65-20172  
LASER OSCILLATIONS AT WAVELENGTHS BETWEEN 21 AND 32 MICRONS FROM PULSED DISCHARGE THROUGH AMMONIA  
N65-20173  
RELAXATION OSCILLATIONS IN EMISSION OF RUBY LASERS UNDER VARIOUS OPERATIONAL CONDITIONS  
T-G-215  
N65-24968  
RESONANT CAVITY, OSCILLATION AND RADIATION OUTPUT OF OPTICAL MASERS  
FTD-TT-64-1231/1G26364  
N66-11458  
TIME DEPENDENCY OF COUPLED MODE LASER OSCILLATION  
UCRL-7497  
N66-20355
- OSCILLATION FREQUENCY**  
ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS LASER WITH PLANE PARALLEL MIRRORS  
A65-15458  
LASER OSCILLATION FREQUENCY AND AMPLITUDE FLUCTUATIONS MEASURED BY DELAY LINE AND SQUARE LAW DETECTOR  
A65-20510  
LASER OSCILLATION WHEREIN LASER MODES OSCILLATE WITH APPROXIMATELY FM PHASES THEREBY COMPRISING SIDEBANDS OF FM LIGHT SIGNAL  
A65-21876  
RUBY LASER ROD POSITION ALONG INTERFEROMETER AXIS, DETERMINING PRESENCE OF ADJACENT INTERFEROMETER MODES  
A65-25874  
ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS LASER WITH PLANE PARALLEL MIRRORS  
A65-28554  
SPECTROMETER FOR LASER OSCILLATION FREQUENCIES AND MODES ANALYSIS  
A65-29430  
LASER EMISSION WITH VARIABLE RESONATOR LOSSES, CONSIDERING RELATIVELY LOW INITIAL OVERPOPULATION  
A65-35784  
STEADY STATE OSCILLATIONS OF LASERS WITH DISTRIBUTED ENERGY LOSSES  
N65-27236  
NONLINEAR INTERACTION OF OSCILLATIONS OF TWO TYPES IN LASER DOES NOT AFFECT STATIONARY OPERATION WHEN OSCILLATIONS ARE SUFFICIENTLY APART IN BAND  
A66-10724  
OSCILLATION OF MASER WITH SINUSOIDAL DISTRIBUTION OF RESONATOR FIELD ALONG AXIS OF MOLECULAR MOTION  
A66-11843  
FM LASER OSCILLATION THEORY DISCUSSING EFFECT OF ARBITRARY ATOMIC LINE SHAPE, SATURATION, MODE PULLING, POWER OUTPUT, SIDEBAND AMPLITUDE, DISTORTION, ETC  
A66-13954  
HIGHER ORDER CALCULATION OF LASER OUTPUT, NOTING APPROXIMATION METHOD FOR LINEWIDTH PARAMETER AND LAMB DIP SHAPE ACCURACY  
A66-19063  
SPATIALLY INDEPENDENT LASER RATE EQUATION GENERALIZED FOR MULTIMODE EFFECTS, NOTING STEADY STATE OSCILLATION THRESHOLD SINGULARITIES, SPIKING PARAMETERS, ETC  
A66-24560

## OSCILLATOR

SHORT-TERM FREQUENCY INSTABILITY AND FREQUENCY SPECTRA OF HIGHLY STABLE QUARTZ OSCILLATORS MEASURED, USING DOUBLE-BEAM AMMONIA MASER AS STANDARD A65-18320

CONTINUOUSLY PULSED LASER DEVICE WITH SELF-CONTAINED LASER OSCILLATOR AND POWER SUPPLY - LASER HEADS USING TUNGSTEN LAMPS AND XENON FLASHLAMP FOR PUMP EXCITATION REPT.-2 N65-27581

THEORY AND APPLICATION OF MASERS AND LASERS - CESIUM, HELIUM-NEON, AND RUBY MASER OSCILLATOR SYSTEMS N65-31361

INTENSITY FLUCTUATIONS IN OUTPUT OF FOUR-LEVEL CW LASER OSCILLATORS BY LINEARIZED RATE EQUATIONS A66-18434

CROSS CORRELATION MEASUREMENTS OF OSCILLATOR FREQUENCY STABILITY AND THERMAL NOISE AND APPLICATION TO ATOMIC HYDROGEN MASER A66-24128

SELF-SUSTAINED RUBIDIUM 87 MASER OSCILLATOR N66-10395

PULSED LASER OSCILLATOR - ADVANCED DEVELOPMENT MODEL ECOM-00326-4 N66-12398

OPTICAL MARGINAL OSCILLATOR DEVELOPMENT IN RESEARCH TOWARD TUNABLE COHERENT LIGHT SOURCE REPT.-8071 N66-14034

SOLID STATE OPTICAL MASER RESEARCH - YTTRIUM-ALUMINUM-GARNET NEODYMIUM LASER OSCILLATOR AS REGENERATIVE NOISE AMPLIFIER - AMPLITUDE FLUCTUATIONS QR-7 N66-14272

LUMINESCENCE IN RARE EARTH DOPED II-VI COMPOUNDS AND SPECTRAL EMISSION CHARACTERISTICS OF LASER OSCILLATORS ML-1346 N66-16740

SPECTRAL EMISSION CHARACTERISTICS OF LASER COHERENT OSCILLATOR N66-16742

## OXIDE

CRYSTAL GROWTH OF INORGANIC OXIDES FOR LASER APPLICATIONS AD-611416 N65-22952

INORGANIC LASER MATERIALS - UNARY AND BINARY OXIDES AD-466008 N65-34473

## OXYGEN

NOBLE GAS-OXYGEN LASER OPERATION UNDER O13 TRIPLE P EXCITATION THROUGH COLLISION-INDUCED OXYGEN DISSOCIATION, NOTING BANDWIDTHS AND OSCILLATIONS A65-21810

NOBLE GAS-OXYGEN LASER OPERATION UNDER O13 TRIPLE P EXCITATION THROUGH COLLISION-INDUCED OXYGEN DISSOCIATION, NOTING BANDWIDTHS AND OSCILLATIONS A65-24862

OXYGEN AS CAUSE OF SCATTERING AND CONVERSION OF IMPURITIES TO HIGHER VALENCE STATE IN CALCIUM FLUORIDE LASER SYSTEM A65-30800

RAYLEIGH SCATTERING USING LASER LIGHT FOR DETERMINATION OF SCATTERING DENSITY OF ARGON, OXYGEN, AND NITROGEN R-135 N65-26127

GAS SPECTROSCOPY OF LASER-INDUCED STIMULATED BRILLOUIN EFFECT IN HIGH PRESSURE OXYGEN A66-23432

## P

## P-I-N DIODE

OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER AS TRANSMITTER AND SILICON P-I-N PHOTODIODE AS DETECTOR USED AS AIRCRAFT ALTITUDE

## P-N JUNCTION

OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER BY P-N TRANSITIONS TO INCREASE POWER AND DIRECTIVITY OF EMISSION A65-17319

FORWARD BIASED P-N JUNCTION ELECTROLUMINESCENCE THEORY AND APPLICATIONS TO DIODE LASERS A65-18872

PHYSICAL CONDITIONS FOR OBTAINING LASER EFFECT IN P-N JUNCTION AND TECHNOLOGY IN CONSTRUCTING LASER DEVICES A65-23847

JUNCTION REGION HEATING OF FABRY-PEROT CA AS INJECTION LASER TREATED BY THREE TECHNIQUES A65-26819

OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER BY P-N TRANSITIONS TO INCREASE POWER AND DIRECTIVITY OF EMISSION A65-30372

RECOMBINATION RADIATION FROM GALLIUM ANTIMONIDE P-N JUNCTIONS, OBSERVING STIMULATED EMISSION AND LASER ACTION A65-30572

TIME PARAMETERS OF POWERFUL LASER MEASURED WITH GA AS PHOTODIODE, NOTING TIME CONSTANT AND TIME RESOLUTION OF PHOTODIODE A65-34552

RADIATIVE TRANSITION PROCESS IN EMISSION SPECTRUM OF GALLIUM ARSENIDE P-N JUNCTION LASER DIODES A65-34666

GALLIUM ARSENIDE LUMINESCENT DIODES WITH TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION AT HIGH DENSITY CURRENT A65-36787

STIMULATED EMISSION FROM GALLIUM ARSENIC P-N JUNCTION LASERS N65-20780

SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION, CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION, FREQUENCY MODULATION LASERS, AND GALLIUM COMPOUND INGOTS FOR LASER APPLICATION AFCRL-64-1007 N65-23135

IMPROVEMENT OF P-N JUNCTION IN GALLIUM ARSENIDE BY INCREASING QUANTUM EFFICIENCY FOR DIRECT CURRENT STIMULATED ELECTROLUMINESCENCE - LASERS AD-461889 N65-26930

THERMAL LIMITATIONS ON CAPABILITIES OF GALLIUM ARSENIDE P-N JUNCTION LASERS A66-10895

LIGHT EMISSION IN FORWARD BIASED SEMICONDUCTOR P-N JUNCTION A66-12577

OPTICALLY CONNECTED LASER CONSTRUCTED ON GALLIUM ARSENIDE P-N JUNCTION, NOTING COHERENT RADIATION A66-14363

GALLIUM ARSENIDE P-N JUNCTION LASER DIODE COVERING INJECTION CURRENT DISTRIBUTION, DENSITY AND EMISSION SPECTRA VARIATION A66-14659

GALLIUM ARSENIDE LUMINESCENT DIODES WITH TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION AT HIGH DENSITY CURRENT A66-19195

HOLE AND ELECTRON SHEARING AND P-TYPE ABSORPTION INFLUENCE ON THRESHOLD CURRENT A66-23478

LIGHT EMISSION FROM GALLIUM ARSENIDE SEMICONDUCTOR P-N JUNCTION INJECTION LASER NOTS-TP-3655 N66-19703

## PACKING DENSITY

COHERENT LIGHT RECORDING AND REPRODUCING SYSTEM COMPRISING TWO-DIMENSIONAL QUANTUM MECHANICAL DATA PROCESS OF ULTIMATE PACKING DENSITY AND FREQUENCY BANDWIDTH RADC-TR-65-130 N65-35528

## PARABOLIC EQUATION

CONSISTENT THEORY OF NONLINEAR OPTICAL EFFECTS IN BOUNDED LIGHT BEAMS BY EXTENDING PARABOLIC EQUATIONS TO NONLINEAR PROBLEMS

- A66-24888
- PARAMAGNETIC AMPLIFIER**  
 MASER AMPLIFIER WITH COUPLED ACTIVE RESONATORS  
 OPERATING AT 21 CM WAVELENGTH, NOTING ADVANTAGE  
 OVER PASSIVE INPUT CIRCUIT A65-14136
- QUANTUM ACTIVE PARAMAGNETIC AMPLIFIER IN FORM OF  
 SERIES-COUPLED RESONATORS, NOTING BANDWIDTH  
 DEPENDENCE ON RESONATOR NUMBER AND DECOUPLING  
 INDEPENDENCE A65-14137
- MASER AMPLIFIER WITH COUPLED ACTIVE RESONATORS  
 OPERATING AT 21 CM WAVELENGTH, NOTING ADVANTAGE  
 OVER PASSIVE INPUT CIRCUIT A65-24011
- QUANTUM ACTIVE PARAMAGNETIC AMPLIFIER IN FORM OF  
 SERIES-COUPLED RESONATORS, NOTING BANDWIDTH  
 DEPENDENCE ON RESONATOR NUMBER AND DECOUPLING  
 INDEPENDENCE A65-24012
- TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
 APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
 8-CM BAND A65-24882
- TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
 APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
 8-CM BAND A65-36359
- PARAMAGNETIC RESONANCE**  
 MASER ACTION TAKING INTO ACCOUNT MIXING OF  
 UNPERTURBED SPIN STATES AND DAMPING MECHANISM  
 BETWEEN SPIN MOMENTS AND LOCAL FIELD A65-16267
- MAGNETIC Q-FACTOR DESCRIBING ELECTROMAGNETIC  
 FIELD ENERGY LOSSES IN PARAMAGNETIC MASER  
 CRYSTALS A65-26860
- PARAMETRIC AMPLIFIER**  
 PARAMETRIC GAIN ACCOMPANYING PARAMETRIC  
 AMPLIFICATION OF LIGHT BEAM BY SECOND HARMONIC  
 FREQUENCY OF STIMULATED RADIATION FROM RUBY LASER  
 ADP CRYSTALS A65-24280
- PARAMETRIC CONVERSION OF OPTICAL FREQUENCIES IN  
 CRYSTAL ILLUMINATED BY LASERS A65-28626
- TRENDS IN MASER AMPLIFIERS, DESCRIBING TYPES AND  
 DEVELOPMENT TECHNIQUES A65-31408
- OPTICAL PARAMETRIC AMPLIFICATION INVOLVING THREE  
 WAVES, OPERATION OF HIGH POWER, NEARLY SINGLE  
 MODED RUBY LASER, AND OBSERVATION OF PARAMETRIC  
 INTERACTION AMONG RAMAN-SHIFTED LINES  
 RADC-TDR-64-386 N65-14311
- PARAMETRIC AMPLIFICATION IN ADENOSINE DIPHOSPHATE  
 USING SECONDARY HARMONIC PRODUCED BY RUBY LASER  
 RADC-TDR-64-484 N65-18629
- RADIOMETRIC PERFORMANCE OF SOLID STATE  
 SUPERHETERODYNE RECEIVER COMPARABLE TO THAT  
 OBTAINED WITH MASERS AND PARAMETRIC AMPLIFIERS  
 A66-12437
- OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING  
 POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED  
 POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-15352
- OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING  
 POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED  
 POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-20893
- GC/S NITROGEN-COOLED NONDEGENERATE PARAMETRIC  
 AMPLIFIER, NOTING DESIGN, APPLICATION AND  
 OPERATION CHARACTERISTICS A66-21857
- PARAMETRIC OSCILLATOR**  
 PARAMETRIC EXCITATION OF ACOUSTIC WAVES IN  
 SIMULATED BRILLOUIN SCATTERING  
 REPT.-1935-5 N65-29906
- EQUATIONS OF MOTION GOVERNING INTERACTION OF  
 OPTICAL MODES IN PRESENCE OF TIME-VARYING  
 PARAMETERS A66-24559
- PARTICLE ACCELERATOR**  
 FOCUSED LASER AS ACCELERATING CAVITY FOR CYCLIC  
 PARTICLE ACCELERATOR A66-10328
- PARTICLE DETECTOR**  
 SMALL PARTICLE DETECTION CAPABILITY OF LOW-GAIN  
 HELIUM-NEON GAS LASER ENHANCED BY USE OF STOKES  
 SETTLING LAW AND LAYERED SEDIMENTATION TECHNIQUE  
 A66-14583
- PARTICLE PRODUCTION**  
 GIANT PULSE LASER USED FOR PRODUCTION OF PARTICLES  
 WITH ENERGIES HIGHER THAN TEN BILLION EV A65-25877
- PATTERN RECOGNITION**  
 LENSLESS PHOTOGRAPHY USING LASERS AND HOLOGRAM/  
 INTERFERENCE PATTERNS BETWEEN REFERENCE WAVE AND  
 WAVES SCATTERED BY RECORDED OBJECT/PRODUCING  
 THREE-DIMENSIONAL IMAGES A65-27196
- PERFORMANCE CHARACTERISTICS**  
 HYDROGEN MASER STORAGE BULB CHARACTERISTICS  
 AD-617342 N65-30159
- EFFECTS OF INTENSE ULTRAVIOLET RADIATION ON GLASS  
 MATERIALS, AND PERFORMANCE CHARACTERISTICS OF  
 GLASS LASERS AD-623309 N66-14533
- PERIODIC PROCESS**  
 THEORETICAL STUDY OF RESONANT MODES OF LASER  
 CAVITY WITH END MIRRORS AND PERIODIC  
 REFLECTIVITY AFCL-64-1015 N65-17931
- PERIPHERAL CIRCULATION**  
 PERIPHERAL MODES IN CHELATE LASER, NOTING  
 LUMINESCENCE EMITTED BY AXIS OF CYLINDRICAL CELL  
 AND LATERAL FACE A66-15171
- PERTURBATION THEORY**  
 INDUCED RADIATION AT HIGH PHOTON DENSITIES, NOTING  
 APPLICABILITY OF PERTURBATION THEORY TO  
 MULTIPHOTON RESONANCE RADIATION OF LASERS A66-20344
- PHASE CHANGE**  
 HE- NE LASER INCORPORATED INTO ARM OF  
 INTERFEROMETER USED TO MEASURE FRINGE SHIFT IN  
 SMALL TRANSIENT PLASMA A66-13743
- INTENSITY DISTRIBUTION OF FRINGE SYSTEMS USED TO  
 VERIFY PHASE INVERSION BETWEEN TWO LOBES OF LASER  
 IN TEM-10 MODE A66-17453
- QUANTUM MECHANICAL NONLINEAR THEORY OF INTENSITY  
 AND PHASE FLUCTUATIONS OF HOMOGENEOUSLY BROADENED  
 LASER NOISE A66-22466
- PHASE CONTROL**  
 OPTICAL SIMULATION OF MICROWAVE ANTENNAS WITHOUT  
 DIRECT FREQUENCY SCALING, OBTAINING AMPLITUDE  
 DISTRIBUTION OF LASER RADIATION FIELDS A65-29418
- PHASE DEMODULATOR**  
 COHERENT INTERFERENCE REJECTION, DISCUSSING NOISE  
 AND MODULATOR-LEAKAGE PICKUP REJECTION IN LASER  
 COMMUNICATIONS EXPERIMENTS A66-17217
- PHASE LOCK**  
 EXPERIMENTAL OSCILLATION OF TWO LASERS AT SAME  
 FREQUENCY WITH PHASE DIFFERENCE OF LESS THAN ONE  
 THIRD DEGREE A65-19603
- OPTICAL RESONATOR EFFECTS ON POPULATION  
 DISTRIBUTION IN HELIUM-NEON GAS LASERS DETERMINED  
 FROM SIDE LIGHT MEASUREMENTS A65-21656
- FREQUENCY STABILIZATION OF DOUBLE MODE HELIUM-NEON  
 LASER VIA PHASE LOCK CIRCUIT A65-29411
- GAS LASER DIRECT MODULATION A66-18355
- PHASE-LOCKING EFFECT AND PHASE SUM OF LF AND HF  
 OSCILLATING MODES IN LASER A66-18413

# SUBJECT INDEX

# PHOTOELECTRIC APPARATUS

- PHASE MODULATION**  
OPTICAL PHASE MODULATOR USING FERROELECTRIC  
BARIUM TITANATE CRYSTAL PLATE A66-10240
- PHASE SHIFT**  
CARNAHAN PROPOSED FIRST ORDER ETHER DRIFT  
EXPERIMENT USING TWO LASERS SHOWN TO BE OF SECOND  
ORDER NATURE, NOTING ROLE OF PHASE SHIFTS A66-21656
- PHASE TRANSFORMATION**  
LASER AS THERMAL TOOL IN METAL WORKING PROCESSES  
EXAMINING PHASE TRANSFORMATION A65-20005
- PHASE VELOCITY**  
VELOCITY MATCHED SECOND HARMONIC GENERATION / SHG/  
AND MIXING OBTAINED IN PIEZOELECTRIC LITHIUM  
NIOBATE CRYSTALS A65-19235
- PHASED ARRAY**  
ANGULAR SCANNING OF LASER BEAM FORMING MULTIPLE  
BEAM PHASED ARRAY, MAKING USE OF TIME COHERENCE  
A66-12445
- PHONON**  
PHONON INTERACTION IN CRYSTALS - TRANSIENTLY  
OPERATED ACOUSTIC MASER, INTERACTION OF PHONONS  
WITH IMPURITIES IN GERMANIUM AND SILICON, AND  
HEAT PULSES IN CRYSTALS QTR-7 N65-27746
- BRILLOUIN SCATTERING OF LIGHT BY PHONONS AND  
PHONON MASER IN DERIVATION OF CONSERVATION  
THEOREMS FROM BASIC EQUATIONS A66-18397
- PHONON-PHOTON INTERACTIONS IN OPTICAL SOURCES -  
THEORETICAL DESCRIPTION OF BRAGG AND  
RAMAN-NATH SCATTERING CAUSED BY PROPAGATION OF  
PLANE ACOUSTIC WAVE THROUGH LASER BEAM PATH  
AFOSR-65-2647 N66-22449
- PHONON BEAM**  
SIGNAL VELOCITY OF MASERS, AND MICROWAVE PHONON  
ATTENUATION AND PULSED HEAT RADIATION IN SINGLE  
CRYSTAL SEMICONDUCTORS REPT.-8 N65-36734
- PHOSPHIDE**  
GROWTH OF GALLIUM ARSENIDE-PHOSPHIDE COMPOUNDS  
FOR LASER USE AFCRL-65-271 N65-27833
- PHOSPHOR**  
CATHODOLUMINESCENT PHOSPHORS AS LIGHT SOURCE FOR  
LASERS, REDUCING HEAT LIMITATIONS AND ELIMINATING  
INTERNAL STRESSES CAUSED BY THERMAL GRADIENTS  
A65-30436
- HIGH INTENSITY ULTRAVIOLET RADIATION SOURCE TO  
PUMP PHOSPHORS AND LASER MATERIALS WITH  
ABSORPTION BANDS IN PHOSPHOR EMISSION SPECTRUM  
DDRF-173 N65-14365
- OPTICAL LASER PUMPS, HIGH POWER CW LASER  
OPERATION BY CATHODOLUMINESCENCE AND SUITABLE  
SELECTION OF PHOSPHORS A66-19546
- PHOSPHORESCENCE**  
EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING  
SPECTRAL RANGE, DURATION, ELECTRON EXCITATION  
MECHANISM AND UPPER WAVELENGTH LIMIT A66-19667
- EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING  
SPECTRAL RANGE, DURATION, ELECTRON EXCITATION  
MECHANISM AND UPPER WAVELENGTH LIMIT A66-21834
- PHOTOCATHODE**  
PHOTOELECTRONS EMITTED BY PHOTOCATHODE LIT BY HEAT  
SOURCE AND LASER COUNTING NUMBER OF AVALANCHES  
DURING GIVEN TIME A65-18037
- ANODE-CURRENT SPECTRUM OF PHOTOMULTIPLIER  
ILLUMINATED BY LIGHT OF TIME-VARYING INTENSITY AND  
DERIVATION OF MOMENTS OF PHOTOELECTRON COUNTS  
A66-18432
- LASER RANGING VIA DIGITAL COUNTER COUPLED
- PHOTOMULTIPLIER TUBE, NOTING SPECTRAL RESPONSE,  
GAIN TRANSIT TIME DEPENDENCE, OUTPUT COUPLING AND  
EFFECTIVE CATHODE DIAMETER A66-23759
- IMPROVED QUANTUM EFFICIENCY FROM LIGHT TRAPPED IN  
TRANSLUCENT PHOTOCATHODE LASER DETECTORS  
ITTIL-66-1002 N66-20166
- PHOTOCHEMICAL REACTION**  
PHOTOCHEMICAL BEHAVIOR OF METAL PHTHALOCYANINES  
IN PRODUCING GIANT PULSES FROM RUBY LASER N65-23435
- PHOTOCONDUCTIVITY**  
FLUORESCENCE FROM CADMIUM SULFIDE EXCITED BY RUBY  
LASER COMPARED WITH PHOTOCONDUCTIVITY INDUCED BY  
ORDINARY GREEN LIGHT TO SUPPORT DOUBLE PHOTON  
ABSORPTION MECHANISM A65-34665
- PHOTOCONDUCTOR**  
OPTICAL PUMPING IN DARK RUBY, HARMONIC GENERATION  
IN HYDROGEN CYANIDE, SUBMILLIMETER WAVE  
SPECTROSCOPY, AND MIXING OF LASER LIGHT IN BULK  
PHOTOCONDUCTOR N65-26426
- PHOTODETECTOR**  
DEVICES OBTAINING INFORMATION FROM MODULATED LASER  
BEAMS INCLUDING PHOTOEMISSIVE DETECTORS AND SOLID  
STATE PHOTODETECTORS A65-23964
- PHOTODIODE**  
INTERNAL MODULATION OF GAS LASER BY GERMANIUM  
PHOTODIODE INVERSELY POLARIZED AND MOUNTED IN  
COAXIAL CIRCUIT A65-16385
- MICROWAVE AMPLIFICATION ACHIEVED IN SILICON DIODE  
EXHIBITING MICROPLASMA-FREE AVALANCHE  
MULTIPLICATION A65-19227
- TIME PARAMETERS OF POWERFUL LASER MEASURED WITH  
GA AS PHOTODIODE, NOTING TIME CONSTANT AND TIME  
RESOLUTION OF PHOTODIODE A65-34552
- THRESHOLD INTENSITY OF 8400 ANGSTROM LIGHT FROM  
GALLIUM ARSENIDE LASER DIODE AND EYE DAMAGE  
A65-34663
- GALLIUM ARSENIDE LUMINESCENT DIODES WITH  
TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION  
AT HIGH DENSITY CURRENT A65-36787
- RADIATION DAMAGE AND ANNEALING OF GALLIUM ARSENIDE  
LASER DIODE A66-14979
- RECORDING SAMPLING SYSTEM FOR MEASURING ENERGY  
INCIDENT ON BIOLOGICAL SYSTEM EXPOSED TO LASER  
BEAM A66-17293
- GALLIUM ARSENIDE LUMINESCENT DIODES WITH  
TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION  
AT HIGH DENSITY CURRENT A66-19195
- PHOTODISSOCIATION**  
ATOMIC AND MOLECULAR FLUORESCENCE EXCITED BY  
PHOTODISSOCIATION, DISCUSSING LINE STRENGTH AND  
DOPPLER WIDTH A65-20073
- GAS LASER OUTPUT AND THRESHOLD IN POPULATION  
INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE  
AND FLUORO IODO METHYLIDYNE A66-16771
- PHOTOELASTICITY**  
GASEOUS AND RUBY LASERS AS LIGHT SOURCES FOR  
PHOTOELASTICITY TEAM-276 N65-29794
- DYNAMIC STRESS CONCENTRATION USING PHOTOELASTICITY  
AND RUBY LASER LIGHT SOURCE TEAM-285 N66-20850
- PHOTOELECTRIC APPARATUS**  
TRAVELING-WAVE TUBE WITH PHOTOELECTRIC CATHODE  
USED AS DEMODULATOR FOR LASER COMMUNICATION  
A65-14345
- HIGH SENSITIVITY FAST-RESPONSE LASER DETECTION  
SYSTEM, DESCRIBING MICROWAVE RESPONSE  
PHOTOELECTRIC DETECTOR WITH AMPLIFICATION AND  
MIXING FUNCTIONS A66-22046

- IMPROVED QUANTUM EFFICIENCY FROM LIGHT TRAPPED IN TRANSLUCENT PHOTOCATHODE LASER DETECTORS  
ITIL-66-1002 N66-20166
- PHOTOELECTRIC CELL**  
LASER OUTPUT MEASUREMENT BY PHOTOELECTRIC CELL DEVICE, NOTING CALIBRATION  
ONERA TP 182 A65-19066
- LASER PHOTOMETRY THROUGH PHOTOELECTRIC CELL  
ONERA-TP-182/1964/ N65-28499
- PHOTOELECTRIC EMISSION**  
ENERGY MEASUREMENT OF RUBY LASER INDUCED ELECTRON EMISSION FROM TUNGSTEN A65-20241
- PHOTOELECTRICITY**  
PULSE ENERGY AND POWER OF LASERS UNDER CONTINUOUS OPERATING CONDITIONS MEASURED, USING CALORIMETERS, PHOTOELECTRIC EFFECT OF RADIATION, ETC A66-13205
- PHOTOELECTRON**  
ANODE-CURRENT SPECTRUM OF PHOTOMULTIPLIER ILLUMINATED BY LIGHT OF TIME-VARYING INTENSITY AND DERIVATION OF MOMENTS OF PHOTOELECTRON COUNTS A66-18432
- PHOTOGRAPHIC APPARATUS**  
LASER APPLICATIONS IN PRECISION AND HIGH SPEED MEASUREMENT AND APPLICATION IN PHOTOGRAPHY, LONG DISTANCE METROLOGY AND PLASMA DIAGNOSTICS A65-20003
- COHERENT LASER LIGHT USED IN NEW PHOTOGRAPHIC PROCESS FOR RECORDING LIGHT WAVES INSTEAD OF IMAGE ON LIGHT-SENSITIVE FILM A65-28104
- HIGH SPEED PHENOMENA HOLOGRAMS PRODUCED BY RADIATION FROM PULSED RUBY LASER OPERATED EITHER IN Q-SWITCHED OR CONVENTIONAL MODE A65-35067
- ADAPTABILITY OF LASERS TO SCHLIEREN SYSTEMS - PHOTOGRAPHIC LIGHTING SYSTEMS  
ARL-65-139 N66-14801
- PHOTOGRAPHIC MEASUREMENT**  
LASER BEAM DIVERGENCE AND ENERGY DISTRIBUTION MEASUREMENT, USING WIDE LATITUDE FILM AND THIN CELLULOID MIRROR A65-17432
- LASER TECHNIQUE TO PHOTOGRAPH HYPERVELOCITY PROJECTILES IN FREE-FLIGHT RANGE A66-13248
- PHOTOGRAPHIC FILM USED FOR QUANTITATIVE MEASUREMENTS OF INTENSITY DISTRIBUTION IN Q-SWITCHED LASER BEAM A66-14920
- RUBY LASER HIGH SPEED PHOTOGRAPHY OF CAVITATION DAMAGE TO SOLIDS DUE TO HIGH SPEED JETS FROM COLLAPSING BUBBLES  
E-115.1 N66-21887
- PHOTOGRAPHIC RECORDING**  
LENSLESS PHOTOGRAPHY USING LASERS AND HOLOGRAM/ INTERFERENCE PATTERNS BETWEEN REFERENCE WAVE AND WAVES SCATTERED BY RECORDED OBJECT/PRODUCING THREE-DIMENSIONAL IMAGES A65-27196
- PHOTOGRAPHIC TRACKING**  
LASER BEAM TRACKING OF BEACON EXPLORER SATELLITES  
NASA-TM-X-56631 N66-22191
- PHOTOGRAPHY**  
PHOTOGRAPHIC STUDY OF Q-SWITCHED LASER BEAM PROPAGATING OVER 10-MILE PATH A65-31044
- OPTICAL DATA PROCESSING TECHNIQUES CONSIDERING STORAGE, MANIPULATION, HOLOGRAPHY AND PATTERN RECOGNITION USING MATCHED FILTERS A66-12997
- COHERENT LASER LIGHT FOR CONVENTIONAL AND UNCONVENTIONAL PHOTOGRAPHIC SITUATIONS A66-22670
- PHOTOIONIZATION**  
ION AND FREE ELECTRON PRODUCTION RATE STUDY IN GAS UNDER LASER BEAM ACTION A65-19727
- FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK SHOCK WAVE IN LASER BEAM A66-10263
- FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK SHOCK WAVE IN LASER BEAM A66-13308
- MULTIPHOTON IONIZATION OF XENON ATOM IN POWERFUL ELECTRIC FIELD BY RUBY LASER RADIATION A66-21966
- GAS DISCHARGE BY LASER PULSE, TAKING INTO ACCOUNT PHOTOIONIZATION DUE TO ELECTRON IMPACT A66-24887
- PHOTOLUMINESCENCE**  
PHOTOLUMINESCENCE LINE STRUCTURE OF ZINC SULFIDE AND CADMIUM SULFIDE CRYSTALS DOPED WITH RARE EARTHS - LASER MATERIALS N66-16741
- PHOTOLYSIS**  
FLASH PHOTOLYSIS APPARATUS FOR STUDYING SHORT LIVED CHEMICAL INTERMEDIATES FROM METHYLENE BLUE PSL-102 N66-21833
- PHOTOMETER**  
GAS EFFECTS PRODUCED BY PULSED LASER BEAM IN BALLISTIC TORSIONAL PENDULUM PHOTOMETER, NOTING DEFLECTION DUE TO PHOTON MOMENTUM EXCHANGE A65-32229
- PHOTOMETRY**  
LASER OUTPUT MEASUREMENT BY PHOTOELECTRIC CELL DEVICE, NOTING CALIBRATION  
ONERA TP 182 A65-19066
- LASER PHOTOMETRY THROUGH PHOTOELECTRIC CELL  
ONERA-TP-182/1964/ N65-28499
- PHOTOMULTIPLIER**  
PHOTOMULTIPLIER AS LASER MONITOR EVALUATED IN TERMS OF PROBABILITY DENSITY FUNCTION A65-26828
- ULTIMATE SENSITIVITY LIMIT AND PHOTOELECTRON STATISTICS FOR PHOTOMULTIPLIER LIT BY COHERENT AND NONCOHERENT LIGHT A66-12473
- ANODE-CURRENT SPECTRUM OF PHOTOMULTIPLIER ILLUMINATED BY LIGHT OF TIME-VARYING INTENSITY AND DERIVATION OF MOMENTS OF PHOTOELECTRON COUNTS A66-18432
- LASER RANGING VIA DIGITAL COUNTER COUPLED PHOTOMULTIPLIER TUBE, NOTING SPECTRAL RESPONSE, GAIN TRANSIT TIME DEPENDENCE, OUTPUT COUPLING AND EFFECTIVE CATHODE DIAMETER A66-23759
- PHOTON**  
TRIGGERING OF BREAKDOWN OF NOBLE GASES SUBJECTED TO RUBY LASER RADIATION BY MULTIPHOTON IONIZATION  
REPT.-1935-3 N65-22851
- COMPUTER ANALYSIS DETERMINING CHANGE OF POPULATION INVERSION AND OUTPUT PHOTON FLUX AND EXPERIMENT USING RUBY FOR OSCILLATOR AND AMPLIFIER USING TRAVELING WAVE MASER IN TRIANGULAR CONFIGURATION  
GSP/PHYS/65-14 N65-31091
- EFFECT OF HIGH VELOCITY TRANSLATION ON PHOTON CORRELATIONS IN LASER INTERFEROMETERS  
UCRL-14345 N66-10969
- PHONON-PHOTON INTERACTIONS IN OPTICAL SOURCES - THEORETICAL DESCRIPTION OF BRAGG AND RAMAN- NATH SCATTERING CAUSED BY PROPAGATION OF PLANE ACOUSTIC WAVE THROUGH LASER BEAM PATH  
AFOSR-65-2647 N66-22449
- PHOTON ABSORPTION**  
RELATION BETWEEN OPTICAL COHERENCE AND PHOTON STATISTICS, USING CLASSICAL AND QUANTUM THEORY, INTERFERENCE EXPERIMENTS AND PHOTODETECTION

- A65-24002
- MULTIPHOTON ABSORPTION IN LASER GA AS AND RUBY CRYSTAL OF OPTICAL GENERATOR A65-26025
- EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF FORBIDDEN BAND IN GALLIUM ARSENIDE A65-31307
- EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF FORBIDDEN BAND IN GALLIUM ARSENIDE A65-33354
- FLUORESCENCE FROM CADMIUM SULFIDE EXCITED BY RUBY LASER COMPARED WITH PHOTOCONDUCTIVITY INDUCED BY ORDINARY GREEN LIGHT TO SUPPORT DOUBLE PHOTON ABSORPTION MECHANISM A65-34665
- DOUBLE PHOTON ABSORPTION, HARMONIC GENERATION, AND FREQUENCY MIXING IN SEMICONDUCTORS, AND FREQUENCY TUNING OF INJECTION LASERS BY UNIAXIAL STRESS AD-450756 N65-14437
- MULTIPHOTON ABSORPTION IN LASER GA AS AND RUBY CRYSTAL OF OPTICAL GENERATOR A66-11727
- CD S SINGLE CRYSTAL OPTICAL GENERATOR DURING EXCITATION BY RUBY LASER, DISCUSSING TWO-PHOTON ABSORPTION COEFFICIENT AT 300 DEGREES K FOR RADIATION FLUX DENSITIES A66-13874
- HYDROGEN MOLECULE MULTIPHOTON IONIZATION, DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY RUBY LASER EMISSION A66-16517
- HYDROGEN MOLECULE MULTIPHOTON IONIZATION, DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY RUBY LASER EMISSION A66-20898
- PHOTON BEAM
- PHOTON TRAPPED WAVE EFFECT FOR DEVELOPING OPTICAL WAVEGUIDES IN WHICH OPTICAL BEAM CREATES WAVEGUIDE AS IT PROPAGATES A66-16662
- LASER SCATTERING BY BOUND CHARGED PARTICLES A66-23080
- PHOTON DENSITY
- ATOMIC RELAXATION AND FLUCTUATIONS OF LASER PHOTONS DETERMINED BY ADDING PROBABILITY AMPLITUDES A65-20744
- SUPPRESSING PULSED LASER SPIKING BY PROVIDING EQUILIBRIUM PHOTON DENSITY AS THRESHOLD IS REACHED, NOTING CASE OF RUBY LASER A65-21300
- PHOTON TRANSPORT AND POPULATION INVERSION IN ACTIVE MEDIUM WITH PUMPING EFFECT, CONSIDERING INTENSE BEAM INCIDENCE AND RUBY LASER A65-36712
- INDUCED RADIATION AT HIGH PHOTON DENSITIES, NOTING APPLICABILITY OF PERTURBATION THEORY TO MULTIPHOTON RESONANCE RADIATION OF LASERS A66-20344
- PHOTON-ELECTRON INTERACTION
- AMPLITUDE NOISE MEASUREMENT FOR CAVITY TYPE GASEOUS OPTICAL MASER OSCILLATOR ABOVE AND BELOW THRESHOLD A65-19544
- LASER EMISSION FROM N TYPE GALLIUM ARSENIDE CRYSTAL BY FAST ELECTRON EXCITATION, NOTING DOPING AND EMISSION ENERGY A65-19546
- ION AND FREE ELECTRON PRODUCTION RATE STUDY IN GAS UNDER LASER BEAM ACTION A65-19727
- LASER BEAM INTERACTION WITH METAL FORM OF THERMAL, MULTIPLE PHOTON AND ELECTRIC FIELD EFFECT A65-27427
- COMPTON SCATTERING OF LASER PHOTONS, NOTING TRANSFORMATION INTO GAMMA RADIATION PHOTONS UPON COLLISION WITH HIGH ENERGY ELECTRONS
- A66-17816
- ANODE-CURRENT SPECTRUM OF PHOTOMULTIPLIER ILLUMINATED BY LIGHT OF TIME-VARYING INTENSITY AND DERIVATION OF MOMENTS OF PHOTOELECTRON COUNTS A66-18432
- INDUCED RADIATION AT HIGH PHOTON DENSITIES, NOTING APPLICABILITY OF PERTURBATION THEORY TO MULTIPHOTON RESONANCE RADIATION OF LASERS A66-20344
- PHOTONIC PROPULSION
- PHOTON ROCKET ENGINE USING PLASMA LASER EMISSION A65-18375
- PHOTOTUBE
- ELECTROSTATIC IMAGE CONVERTER CAMERA USED IN PLASMA AND LASER RESEARCH FOR HIGH SPEED WRITING A65-32585
- TRANSVERSE ELECTRON-BEAM WAVE EXCITATION BY PHOTOELECTRIC MIXING OF LASER BEAMS A65-32874
- PHOTOTUBE OBSERVATION OF RUBY LASER OUTPUT AS FUNCTION OF TIME N65-15570
- PIEZOELECTRIC CRYSTAL
- VELOCITY MATCHED SECOND HARMONIC GENERATION / SHG/ AND MIXING OBTAINED IN PIEZOELECTRIC LITHIUM NIOBATE CRYSTALS A65-19235
- LASER EXCITATION IN QUARTZ OF ELASTIC MODES OF THICK PLATE, SUGGESTING ENERGY COUPLING MECHANISMS A66-12423
- POSSIBLE MATERIALS FOR SECOND HARMONIC GENERATION AND LASER ACTION DISCUSSING CENTROSYMMETRIC AND PIEZOELECTRIC CRYSTALS AND SINGLE CRYSTAL PLATE WITH ALTERNATE LAYERS OF NONCENTROSYMMETRIC COMPOSITION A66-12940
- PIEZOELECTRIC PRESSURE GAUGE
- PROCESSING EVAPORATED CADMIUM SULFIDE THIN FILMS TO ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING LASER-INDUCED ELASTIC VIBRATIONS A65-21875
- EVAPORATED CADMIUM SULFIDE THIN FILMS PROCESSED TO ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING LASER-INDUCED ELASTIC VIBRATION A65-31942
- PIEZOELECTRICITY
- PIEZOELECTRICALLY POWERED LASER BEAM WAVEGUIDE FOR ELECTRO-OPTICAL ACQUISITION AND TRACKING NASA-CR-68895 N66-17291
- PIGEON
- EFFECT OF LASER IRRADIATION ON INNER EAR IN PIGEONS A66-80961
- PINCH EFFECT
- QUANTUM ELECTRODYNAMICS IN OPTICAL RESONATORS AND MASERS, THERMAL PINCHING, N-TYPE SEMICONDUCTORS, COHERENT LIGHT, TRANSISTOR SWITCHING, POPULATION INVERSION, AND BREAKDOWN AFOSR-65-0248 N65-23491
- ELECTRON TEMPERATURE AND DENSITY MEASUREMENTS OF 26 K JOULE THETA-PINCH BY LIGHT SCATTERING FROM COMBINED OSCILLATOR-AMPLIFIER LASER IPP-1/42 N66-21141
- PLANE WAVE
- PLANE STATIONARY MODE OF TW LASER AMPLIFIER WITH FEEDBACK A65-19683
- LOSSLESS CONVERSION OF PLANE LASER WAVE TO PLANE WAVE OF UNIFORM IRRADIANCE, NOTING PLANOASPHERIC LENSES METHOD AND ABERRATED LENS SYSTEM A66-12204
- PLANETARY ATMOSPHERE
- LECTURE MANUSCRIPTS ON HIGH ALTITUDE EXPLOSIONS, BIOLOGICAL EXPLORATION OF MARS, MASERS AND LASERS, PLANETARY ATMOSPHERES, RELATIVITY THEORY, ELEMENT ABUNDANCE, AND SOLAR PARTICLES



# PLANETARY EXPLORATION

# SUBJECT INDEX

- N65-31360  
**PLANETARY EXPLORATION**  
 LECTURE MANUSCRIPTS ON HIGH ALTITUDE EXPLOSIONS, BIOLOGICAL EXPLORATION OF MARS, MASERS AND LASERS, PLANETARY ATMOSPHERES, RELATIVITY THEORY, ELEMENT ABUNDANCE, AND SOLAR PARTICLES  
 N65-31360
- N ASA PROGRAM OF ADVANCED SPACE RESEARCH AND TECHNOLOGY - PLANETARY EXPLORATION, ENERGY CONVERSION, MATERIALS SCIENCE, AND LASERS  
 N66-12404
- PLANETARY SPACECRAFT**  
 EFFECTS OF PROPAGATION TIMES ON STEERING NARROW BEAM LASER FOR COMMUNICATIONS BETWEEN PLANETARY DEEP-SPACE VEHICLE AND EARTH GROUND STATION OR RELAY STATION - SPACIAL BEAM OFFSET  
 NASA-TM-X-55306  
 N66-11202
- PLASMA**  
 HIGH VOLTAGE, POWER, AND ENERGY FACILITIES FOR RADAR, LASERS, PLASMAS, AND COMMUNICATION COMPONENTS RESEARCH  
 EB-5288-0536  
 N65-21673
- ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASER, TUNABLE LASER, GEOMETRICAL OPTICS, SEMICONDUCTOR OSCILLATION, AND SOLID STATE PLASMA STUDIES FOR MICROWAVE TRANSMISSION  
 ML-1316  
 N65-27969
- ELECTRON BEAMS, PLASMA, AND LASERS AND MASERS FOR EXTENDING USEFUL FREQUENCY SPECTRUM INTO RANGE FROM MICROWAVE TO OPTICAL FREQUENCIES  
 MDL-Q12  
 N65-28149
- ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASERS, TUNABLE LASERS, ELECTRON-PROTON INTERACTIONS, SEMICONDUCTORS, GEOMETRIC OPTICS, AND SOLID STATE PLASMA STUDIES  
 ML-1351  
 N65-34887
- PLASMA ACCELERATION**  
 PLASMA RESEARCH - SOLIDS, LIQUIDS, HEATING AND ACCELERATION BY HIGH AMPLITUDE ELECTROMAGNETIC FIELDS, LASER PRODUCED, ELECTRON HEATING AND REFLECTION, AND OPTICAL INTERACTIONS  
 N66-10960
- PLASMA ACCELERATOR**  
 PRODUCTION OF ION VELOCITIES OVER 4 KM/SEC BY FOCUSED RUBY LASER MAKES PRACTICAL APPLICATION IN DIRECT THRUSTORS AND AS PLASMA SOURCE IN ACCELERATOR TYPE THRUSTORS  
 A65-23626
- TRAVELING FIELDS IN INTERACTION OF IONIZED GASES WITH ELECTROMAGNETIC FIELD CURRENTS CHECKING LORENTZ FORCE AND MAGNETIC INDUCTION  
 A66-12980
- PLASMA ARC WELDING**  
 FOCUSED ENERGY TECHNIQUES FOR JOINING, INCLUDING LASER WELDING  
 ASTME PREPRINT AD66-718  
 A66-24413
- PLASMA CLOUD**  
 DENSITY, TEMPERATURE AND SPEED OF EXPANSION OF PLASMA CLOUD PRODUCED BY IMPACT OF RUBY LASER BEAM ON ALUMINUM STRIP  
 A65-29558
- PLASMA CONFINEMENT**  
 METALLIC PLASMA TUBE FOR ION LASERS ALLOWS THEM TO RUN AT HIGHER CURRENT DENSITIES THAN WITH CERAMIC TUBES  
 A66-11373
- PLASMA DECAY**  
 PLASMA DECAY IN PULSE DISCHARGE OF HELIUM-NEON LASER GRAPHICALLY DEPICTED UNDER CONDITIONS OF GENERATION  
 A65-31878
- PULSE-DISCHARGE PLASMA DECAY STUDIED BY OBSERVATION OF GENERATION PROCESSES IN HELIUM-NEON PULSE LASER  
 A65-33584
- ELECTRON DENSITY AND COLLISION FREQUENCY MEASUREMENTS IN TRANSIENT OSCILLATION OF IR AND VISIBLE HELIUM-NEON LASERS TO DETERMINE
- RELATIONSHIP BETWEEN OSCILLATIONS AND PLASMA PARAMETERS  
 A65-34806
- PLASMA DENSITY**  
 FREQUENCY RESPONSE AND CROSS COUPLING OF RED AND IR GAS LASER INTERFEROMETER FOR MEASURING PLASMA ELECTRON DENSITY  
 A65-15819
- GAS LASER INTERFEROMETERS FOR PLASMA LOW ELECTRON DENSITY MEASUREMENT  
 A66-10856
- MEASUREMENT OF ELECTRON DENSITY OF GAS DISCHARGE PLASMA BY LASER INTERFEROMETER  
 A66-16379
- PLASMA DISCHARGE**  
 LASER OSCILLATION IN VISIBLE REGION FROM PULSED COLD CATHODE DISCHARGE IN IONIZED S AND P  
 A65-33379
- GAS LASER EMISSION SOLUTION BY DETERMINING EMISSION FIELD DENSITY DEPENDENCE ON RESONATOR PARAMETERS, RELAXATION CHARACTERISTICS AND ATOM EXCITATION IN GAS DISCHARGE PLASMA  
 A65-35868
- PLASMA RING DISCHARGE EXCITATION USED TO DRIVE HIGH CURRENT DENSITY ELECTRODELESS ARC FOR EXCITING GAS ION LASER TRANSITIONS  
 A66-10967
- GAS LASER EMISSION SOLUTION BY DETERMINING EMISSION FIELD DENSITY DEPENDENCE ON RESONATOR PARAMETERS, RELAXATION CHARACTERISTICS AND ATOM EXCITATION IN GAS DISCHARGE PLASMA  
 A66-19271
- LONGITUDINAL MAGNETIC FIELD EFFECT UPON GAS DISCHARGE, ZEEMAN EFFECT AND FARADAY EFFECT IN HE- NE GAS LASER  
 A66-24224
- PLASMA DYNAMICS**  
 PLASMA KINETIC PROCESSES IN NE- HE LASER LEADING TO POPULATION INVERSION  
 A65-27738
- PLASMA KINETIC PROCESSES IN NE- HE LASER LEADING TO POPULATION INVERSION  
 A65-31843
- PLASMA-ELECTROMAGNETIC INTERACTION**  
 ANGULAR WIDTH AND INTENSITY OF LIGHT FROM TWO LASERS THAT CAUSE PLASMA TO OSCILLATE AND IN TURN ARE SCATTERED BY INDUCED FLUCTUATIONS  
 A66-14328
- QUANTUM THEORY OF INTERACTION OF ELECTROMAGNETIC WAVES IN PLASMA CONSIDERED IN TERMS OF LIGHT-LIGHT SCATTERING AND PLASMA-LASER BEAM INTERACTION  
 A66-21173
- DIFFUSION OF LIGHT BY PLASMA ELECTRONS PRODUCED IN LABORATORY FOR VERY SMALL EFFECTIVE DIFFUSION AREA  
 A66-21712
- PLASMA GENERATION**  
 PLASMA PRODUCTION USING GIANT LASERS FOCUSED ON SMALL SPECKS OF SOLID MATERIAL  
 A65-30792
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM, NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
 A65-35877
- PULSED LASER-CREATED PLASMAS BY LIGHT ABSORPTION BY SKIN EFFECT  
 A66-12975
- PLASMA GENERATION BY FOCUSING LASER BEAM IN AIR AT ATMOSPHERIC PRESSURE AND ROOM TEMPERATURE INDICATE CONNECTION WITH LUMINOUS ENERGY ABSORPTION DURING BREAKDOWN  
 A66-14538
- EVOLUTION OF LUMINOUS ZONE OF PLASMA GENERATED BY FOCUSING LASER BEAM IN AIR  
 A66-15097
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM, NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
 A66-18972
- PLASMA PRODUCTION BY OPTICAL IRRADIATION OF GASES AND BY SOLIDS, CONSIDERING INTERACTION OF LASER RADIATION WITH SURFACES AND IRRADIATION OF PARTICLES OF SOLID MATERIAL IN VACUUM

- AIAA PAPER 66-174 A66-22212
- PLASMA HEATING**  
LASER EMISSION USED FOR HEATING PLASMA WITH INITIAL DENSITY NEAR ZERO A65-15535
- DENSE HIGH-TEMPERATURE HYDROGEN PLASMA PRODUCTION BY INTENSE LASER PULSE HEATING OF MAGNETICALLY CONTAINED PLASMA A65-29978
- PLASMA RESEARCH - SOLIDS, LIQUIDS, HEATING AND ACCELERATION BY HIGH AMPLITUDE ELECTROMAGNETIC FIELDS, LASER PRODUCED, ELECTRON HEATING AND REFLECTION, AND OPTICAL INTERACTIONS N66-10960
- ESTIMATION OF PLASMA HEATING BY LASERS NRC-TT-1193 N66-10962
- PLASMAS HEATED BY LASERS TO TEMPERATURES OF INTEREST TO THERMONUCLEAR CONDITIONS PRODUCE NONRESONANT IONIZATION NRC-TT-1193 N66-17933
- PLASMA INSTABILITY**  
HE- NE LASER INCORPORATED INTO ARM OF INTERFEROMETER USED TO MEASURE FRINGE SHIFT IN SMALL TRANSIENT PLASMA A66-13743
- PLASMA JET**  
LABORATORY RESEARCH ON LASER EXCITATION IN SOLIDS, IONIZING RADIATION TRANSMISSION AND PLASMA JETS RELATED TO ASTROPHYSICS A65-14678
- TREATMENT OF STEEL WITH LASER BEAM, OBTAINING PRECISION HOLES WITHOUT AFFECTING MICROHARDNESS OF METAL A66-24898
- PLASMA-PARTICLE INTERACTION**  
PLASMA PRODUCTION BY OPTICAL IRRADIATION OF GASES AND BY SOLIDS, CONSIDERING INTERACTION OF LASER RADIATION WITH SURFACES AND IRRADIATION OF PARTICLES OF SOLID MATERIAL IN VACUUM AIAA PAPER 66-174 A66-22212
- PLASMA PHYSICS**  
PLASMA INTERFEROMETRY TECHNIQUE WHERE REFLECTED-BACK OUTPUT OF GAS LASER IS MODULATED, USING PHASE VARIATIONS A65-19754
- PROCEEDINGS OF URSI GENERAL ASSEMBLY ON RADIO ELECTRONICS INCLUDING PLASMAS, MASERS AND LASERS AT TOKYO IN SEPTEMBER 1963 A65-26930
- ELECTROSTATIC IMAGE CONVERTER CAMERA USED IN PLASMA AND LASER RESEARCH FOR HIGH SPEED WRITING A65-32585
- LASER INTERFEROMETER AND APPLICATION TO PLASMA PHYSICS AROD-4832-2 N65-17210
- GASEOUS AND SOLID LASER LINES SURVEY FOR LASER SPECTROSCOPY AND PLASMA DIAGNOSTICS NASA-CR-57334 N65-19752
- LASER INTERFEROMETER TO MEASURE TIME AND SPATIAL VARIATION IN REPETITIVELY PULSED PLASMA A66-10243
- SOVIET AND FOREIGN PAPERS ON PLASMA DIAGNOSTICS BY SCATTERING OF LASER BEAMS AT PLASMA ELECTRONS A66-21990
- ENERGY LEVEL RELATIVE POPULATION DENSITIES OF NEON PLASMA USING HELIUM-NEON LASER - LANGMUIR PROBE ADDITIONS FOR MEASUREMENT OF PLASMA ELECTRON TEMPERATURE AND VELOCITY DISTRIBUTIONS ARL-65-246 N66-22488
- PLASMA PINCH**  
IN SB LONGITUDINAL INJECTION-PLASMA LASER, NOTING PLASMA PINCH AND MODE STRUCTURE A65-17210
- PLASMA POWER SOURCE**  
CONTINUOUSLY PULSED LASER DEVICE WITH SELF-CONTAINED LASER OSCILLATOR AND POWER SUPPLY - LASER HEADS USING TUNGSTEN LAMPS AND XENON
- FLASHLAMPS FOR PUMP EXCITATION REPT.-2 N65-27581
- PLASMA PROBE**  
THOMSON SCATTERED LASER RADIATION USED TO DETERMINE ELECTRON DENSITY IN HELIUM PLASMA, EXAMINING THYRATRON TUBE AND VOLTAGE PROBE USE A65-19618
- MAGNETIC FIELD PROBE IN ELECTROMAGNETICALLY DRIVEN SHOCK TUBE AND COHERENT LIGHT IN IONIZING SHOCK WAVE PLASMA DIAGNOSTICS A65-29569
- TIME RESPONSE OF HF LASER INTERFEROMETER USED IN PLASMA RESONANCE DETECTION A65-29791
- LASER APPLICATION AND TECHNIQUES NOTING AMPLIFICATION, MODULATION, INTERFEROMETRY, SCATTERING, PLASMA DIAGNOSTICS, NONLINEAR OPTICS, ETC A66-23931
- PLASMA RADIATION**  
ELECTRON DENSITY MEASUREMENTS IN PLASMA PRODUCED BY COMBINATION OF RF AND VERY FAST THETA-PINCH DISCHARGES, USING GAS LASER INTERFEROMETER A65-29848
- TIME-DEPENDENT ELECTRON DENSITY VARIATION STUDIED IN FAST THETA-PINCH DISCHARGE, USING HE- NE GAS LASER INTERFEROMETER A65-29849
- LOCAL ELECTRON TEMPERATURE AND ELECTRON DENSITY IN THETA PINCH MEASURED BY MEANS OF SCATTERING OF LASER BEAM A66-14334
- PLASMA RESONANCE**  
LASER INDUCED GAS BREAKDOWN AT HIGH PRESSURES, NOTING EFFECT OF PLASMA DENSITY ON INDEX OF REFRACTION VIA OPTICAL FREQUENCY RESONANCE MEASUREMENT A66-21564
- PLASMA SPECTRUM**  
MULTICHANNEL PHOTOELECTRIC SPECTRUM ANALYZER WITH KERR CELL GATING RECORDS SPECTRUM OF LASER LIGHT SCATTERED FROM SINGLE GIANT PULSE IN PLASMA A65-28203
- PLASMA TEMPERATURE**  
SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER RADIATION, DETERMINING TEMPERATURE OF PLASMA PRODUCED NEAR FOCUS A65-31705
- EXCITATION OF RUBY LASERS USING DOUBLE-PUMPED HIGH-INTENSITY HELICAL FLASH TUBES, OBTAINING TIME-RESOLVED SPECTRA OF ELECTRICAL DISCHARGES AND PLASMA TEMPERATURES A66-11446
- SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER RADIATION, DETERMINING TEMPERATURE OF PLASMA PRODUCED NEAR FOCUS A66-19959
- PLATFORM**  
GAS LASER RANGE MEASUREMENT DEVICE GIVING HIGH ACCURACY DIFFERENTIAL TERRAIN HEIGHT INFORMATION FROM AIRBORNE PLATFORM N65-33571
- PLATINUM**  
PREPARATION OF OPTICALLY HOMOGENEOUS LASER GLASS FREE OF PLATINUM INCLUSIONS BY PLATINUM PASSIVATION OR USING ALL-CERAMIC MELTING SYSTEM SATR-1 N65-22027
- PREPARATION OF PLATINUM-FREE LASER GLASS SATR-2 N66-14672
- POINT-TO-POINT COMMUNICATION**  
LASER BEAM COMMUNICATION BETWEEN DEEP-SPACE VEHICLE AND EARTH TRACKING STATION - CLOSED LOOP SYSTEM AND LEAD ANGLE COMPUTATIONS FOR TARGET MOTION COMPENSATION NASA-CR-60699 N65-16811
- POISSON DISTRIBUTION**  
PHOTOELECTRONS EMITTED BY PHOTOCATHODE LIT BY HEAT SOURCE AND LASER COUNTING NUMBER OF AVALANCHES DURING GIVEN TIME A65-18037
- POLARIZATION**  
DIRECT CURRENT POLARIZATION IN NONLINEAR

## POLARIZATION CHARACTERISTICS

## SUBJECT INDEX

- DIELECTRIC MEDIUM AT OPTICAL FREQUENCY  
TR-EE-64-5 N65-22518
- TWO TYPES OF NONLINEAR INTERACTION OF INTENSE  
LASER BEAM WITH DIELECTRIC MEDIUM - NONLINEAR  
DC POLARIZATION AND SUBHARMONICS GENERATION AT  
OPTICAL FREQUENCIES  
AD-618473 N65-33899
- POLARIZATION CHARACTERISTICS**  
TWO POLARIZATION EIGENSTATES OCCURRING  
REPEITIVELY IN MULTIPLE PASS INTERFEROMETER  
CONTAINING ANISOTROPIC ELEMENTS, WITH PLANAR LASER  
EXAMPLE A65-21662
- POLARIZED LIGHT**  
RUBY LASER TEMPERATURE MEASUREMENT AND FILTERING  
BY DETERMINING SPECTRAL POSITION OF POLARIZATION  
INTERFERENCE BANDS A65-14184
- POLARIZATION EFFECT ON ENERGY DISTRIBUTION AND  
EFFICIENCY IN DIFFRACTION GRATING OF ATTENUATED  
LASER LIGHT A65-16581
- NONLINEAR OPTICAL EFFECTS IN CRYSTALLINE AND  
ISOTROPIC MATERIALS DUE TO INDUCED POLARIZATION  
THIRD ORDER IN ELECTRIC FIELD STRENGTH, USING  
GIANT PULSED LASER SOURCE A65-16863
- REDUCTION OF LOCKING FREQUENCY OF RING LASER BY  
MAKING TWO BEAMS ORTHOGONAL A65-19601
- POLARIZATION OF LIGHT FROM GLASS LASER DOPED WITH  
TWO PERCENT POSITIVE TRIVALENT NEODYMIUM MEASURED  
WITH TIME RESOLUTION OF LESS THAN MICROSECOND  
A66-13006
- INTENSITY OF POLARIZED LIGHT TRANSMITTED THROUGH  
LASER AMPLIFIER AND LINEAR POLARIZER, AS FUNCTION  
OF AXIAL MAGNETIC FIELD STRENGTH A66-17292
- POLARIZED RADIATION**  
POLARIZED LASER RADIATION WITH RELATION BETWEEN  
INTENSITY AND DIPOLE MOMENT OF ANISOTROPY AND  
PUMPING POWER A65-21805
- ROCKET MISSILE ATTITUDE SENSING DURING EARLY  
LAUNCH PHASE USING POLARIZED LASER BEAMS  
TRANSMITTED FROM GROUND STATION A65-23619
- POLARIZED LASER RADIATION WITH RELATION BETWEEN  
INTENSITY AND DIPOLE MOMENT OF ANISOTROPY AND  
PUMPING POWER A65-24857
- CHROMIUM ALIGNMENT IN RUBY BY OPTICALLY PUMPING  
RUBY SAMPLE WITH CIRCULAR POLARIZED RADIATION FROM  
RUBY LASER A65-33418
- CRYSTALLINE CALCITE USED AS DICHROIC POLARIZER IN  
IR REGIONS, LASER RADIATION, ZEEMAN EFFECT AND  
NOISE PROPERTIES MEASUREMENTS, ETC A65-33419
- COMPTON SCATTERING OF LASER PHOTONS, NOTING  
TRANSFORMATION INTO GAMMA RADIATION PHOTONS UPON  
COLLISION WITH HIGH ENERGY ELECTRONS A66-17816
- BEAT FREQUENCY AND ROTATION OF POLARIZATION PLANE  
IN HE-NE LASER WITH AXIAL MAGNETIC FIELD A66-18430
- CROSS SECTION MEASUREMENT FOR ELECTROMAGNETIC  
BACKSCATTERING OF LASER BEAMS FROM ROUGH ALUMINUM  
AND MAGNESIUM OXIDE SURFACES A66-18930
- POLYESTER**  
SELECTED FOREIGN SCIENTIFIC AND TECHNICAL  
LITERATURE ON POTENTIAL THEORY, SEMICONDUCTOR  
LASERS, COMPOSITE PROPELLANTS, AROMATIC,  
POLYESTERS, AND TECTONICS N66-21862
- POLYETHYLENE**  
CONTINUOUS WAVE GAS LASER AND HIGH SPEED MOTION  
PICTURE CAMERA FOR DETECTION OF NEARLY  
CONTINUOUS SET OF LIGHT SCATTERING PHOTOGRAPHS  
FROM POLYETHYLENE POLYMER SAMPLE
- CNR-TR-77 N65-25399
- POLYMER**  
REFRACTIVE INDEX OF SOLID DETERMINED, USING FAR  
IR MICHELSON INTERFEROMETER ILLUMINATED WITH  
RADIATION FROM CN MASER A65-24683
- RESEARCH REPORTS ON CODER COMPONENTS, POLYMERS,  
SPECTROSCOPY, LASERS, ELECTROCHEMISTRY,  
TRANSMISSION LINES, AND SEMICONDUCTOR PHYSICS  
NAVWEPS-8150 N65-15565
- POLYMER CHEMISTRY**  
RESEARCH IN FERROMAGNETISM, POLYMER CHEMISTRY,  
LASERS, SEMICONDUCTORS, AND SOLID STATE  
SPECTROSCOPY  
NAVWEPS-8226 N65-26765
- POLYMERIZATION**  
RADIOMETER MASERS, MICROWAVE GENERATION,  
BIOLOGICAL ASPECTS OF MICROWAVES, POLYMERIZATION  
AND OPTIMAL CONTROL  
AD-455792 N65-18884
- POLYSTYRENE**  
LASER-BEAM SCATTERING BY INDIVIDUALLY INTRODUCED  
CHARGED POLYSTYRENE SPHERICAL PARTICLES AND  
DROPLETS OF NAPHTHALENE AND WATER IN COMBINATION  
A66-17473
- POPULATION**  
GAS LASERS - LEVEL POPULATION DEPENDENCES, LASER  
POWER OUTPUT, METASTABLE DENSITY MEASUREMENTS,  
AND PARAMETER CHANGE EFFECT ON MATHEMATICAL  
MODEL OF LASER SYSTEM  
S-740 N65-20002
- POPULATION INVERSION**  
NORMAL BOLTZMANN DISTRIBUTION INVERSION IN  
MOLECULAR BEAM TO OBTAIN EXCESS UPPER ENERGY  
LEVEL POPULATION FOR MASER OSCILLATION  
A65-15801
- OPTICAL PUMP PULSE SHAPE EFFECT ON POPULATION  
INVERSION ATTAINED IN RUBY LASER A65-16569
- CHEMICAL LASER PRINCIPLE CONSIDERING POPULATION  
INVERSIONS FROM CHEMICAL REACTION A65-20002
- CONFERENCE ON CHEMICAL LASERS, UNIVERSITY OF  
CALIFORNIA AT LA JOLLA IN SEPTEMBER 1964  
A65-20059
- RECENT DEVELOPMENTS IN GAS LASERS WITH ATTENTION  
TO INVERSION MECHANISMS, TWO AND THREE LEVEL  
COLLISION LASERS, ICM LASERS AND CURRENTLY KNOWN  
TRANSITIONS A65-20060
- GAS DISCHARGE COLLISION LASER EFFICIENCY AND POWER  
OUTPUT CONSIDERATIONS WITH ATTENTION TO MANGANESE  
AND LANTHANUM DISCHARGES A65-20062
- CHARGE TRANSFER AS LASER PUMPING TECHNIQUE  
A65-20063
- CHEMICAL PROCESSES PRODUCING SPECTROSCOPICALLY  
OBSERVABLE POPULATION INVERSIONS IN ATOMIC OR  
MOLECULAR LASERS A65-20066
- PARTIAL AND COMPLETE VIBRATIONAL-ROTATIONAL  
POPULATION INVERSION CONDITIONS, DISCUSSING  
VIBRATIONAL STATE CHANGE IN PHYSICAL AND CHEMICAL  
PROCESSES A65-20067
- VIBRATIONAL, ELECTRONIC AND TRANSLATIONAL ENERGY  
TRANSFERS OF GAS MOLECULE COLLISIONS, NOTING  
QUENCHING PROCESS AND FREQUENCY DIFFERENCES  
EFFECT A65-20068
- FLAME EMISSION DATA AND ABSORPTION CHARACTERISTICS  
SUITABLE FOR POPULATION INVERSION FOR LASER  
ACTION, NOTING LOW PRESSURE OXYACETYLENE FLAME  
A65-20070
- CONTINUOUS REGIME OPTICAL GENERATOR OUTPUT,  
THRESHOLD PUMPING LEVEL, INVERSE POPULATION  
DENSITY AND INDUCED RADIATION ENERGY

# SUBJECT INDEX

# POWDERED METAL

A65-20326

PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J AND N TO K CALCULATED WITH GAS LASER A65-21811

RATE EQUATION SOLUTIONS FOR Q-SPOILED AND PULSED TRANSMISSION MODE / PTM/ OPERATION OF THREE-LEVEL LASER A65-22933

PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J AND N TO K CALCULATED WITH GAS LASER A65-24863

PUMP FREQUENCY OF 30 GIGACYCLES USING HARMONIC CROSS RELAXATION ON CHROMIUM DOPED RUTILE TO OBTAIN POPULATION INVERSION AT 40 GIGACYCLE SIGNAL FREQUENCY A65-25873

LASER OPERATION AS PULSED REGENERATIVE OSCILLATOR ARISING FROM MODE COUPLING DUE TO TIME-VARYING LOSS IN CAVITY OR NONLINEAR CHARACTERISTICS OF INVERTED POPULATION A65-27603

MODEL DESCRIPTION AND MATHEMATICAL FORMULATION FOR SPIKE PULSING PHENOMENON OBSERVED IN OPTICALLY PUMPED THREE-LEVEL LASERS A65-27607

PLASMA KINETIC PROCESSES IN NE- HE LASER LEADING TO POPULATION INVERSION A65-27738

E-LEVEL POPULATION IN RUBY ROD AS FUNCTION OF PUMP ENERGY EMITTED BY FLASH TUBE A65-28013

Q-SWITCHING APPLIED TO SLOW SWITCHING AND PULSE SHAPING FOR SOLID STATE LASERS AIAA PAPER 65-343 A65-30797

TIME-VARIATION AND SPONTANEOUS EMISSION FROM HE-HG DISCHARGE OF 6149 ANGSTROM LASER TRANSITION A65-31451

PLASMA KINETIC PROCESSES IN NE- HE LASER LEADING TO POPULATION INVERSION A65-31843

LASER EXCITATION IN FREON AND RARE GAS MIXTURES BASED ON DISSOCIATIVE EXCITATION PROCESS AND QUENCHING ACTION OF SOME GASES A65-35043

ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION DURING OPTICAL PUMPING, NOTING RELATION BETWEEN ENERGY ABSORPTION AND POPULATION INVERSION A65-36055

PHOTON TRANSPORT AND POPULATION INVERSION IN ACTIVE MEDIUM WITH PUMPING EFFECT, CONSIDERING INTENSE BEAM INCIDENCE AND RUBY LASER A65-36712

LASER MODULATION AT ATOMIC LEVEL - POPULATION INVERSION AND ESTIMATE OF ZEEMAN SPLITTING NASA-CR-60572 N65-16320

QUANTUM ELECTRODYNAMICS IN OPTICAL RESONATORS AND MASERS, THERMAL PINCHING, N-TYPE SEMICONDUCTORS, COHERENT LIGHT, TRANSISTOR SWITCHING, POPULATION INVERSION, AND BREAKDOWN AFOSR-65-0248 N65-23491

POPULATION INVERSION AND OPTICAL MASER OSCILLATIONS IN MOLECULAR GASES N65-23497

COMPUTER ANALYSIS DETERMINING CHANGE OF POPULATION INVERSION AND OUTPUT PHOTON FLUX AND EXPERIMENT USING RUBY FOR OSCILLATOR AND AMPLIFIER USING TRAVELING WAVE MASER IN TRIANGULAR CONFIGURATION GSP/PHYS/65-14 N65-31091

PEAK POWER TRANSIENTS OF NEAR CONFOCAL HELIUM-NEON LASER WORKING AT 6328 ANGSTROMS ON PULSED DISCHARGE BASIS A66-10329

ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION INVERSION IN LEVELS OF OPTICAL TRANSITION A66-10448

LASER TRANSITION IN VIBRATIONAL STATE OF GROUND ELECTRONIC STATE OF CN FROM ROTATIONAL LEVEL 8 TO

7 WITH POPULATION INVERSION AS RESULT A66-11451

TWO- AND THREE-STEP LASER CASCADES DETECTED EXPERIMENTALLY IN HELIUM-NEON MIXTURES, ANALYZING TWO-STEP CASCADE STARTING WITH DENSITY MATRIX FORMULATION A66-11477

PHYSICAL FUNDAMENTALS OF LASERS SUCH AS POPULATION INVERSION, INDUCED EMISSION AND PRINCIPAL OPTICAL APPARATUS EXPLAINED FOR COMMUNICATIONS ENGINEERS A66-13233

ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION INVERSION IN LEVELS OF OPTICAL TRANSITION A66-13311

PROPAGATION RATE OF HIGH POWER LASER LIGHT PULSE IN INVERSELY POPULATED MEDIUM A66-15333

ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION DURING OPTICAL PUMPING, NOTING RELATION BETWEEN ENERGY ABSORPTION AND POPULATION INVERSION A66-15858

LASER ACTION ON FIVE GREEN LINES AND SIX IR LINES CAUSED BY PULSING MANGANESE DISCHARGE OF COLLISION LASER IN ATOMIC VAPOR OF NEUTRAL MANGANESE A66-16763

GAS LASER OUTPUT AND THRESHOLD IN POPULATION INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE AND FLUORO IODO METHYLDIYNE A66-16771

DERIVATION OF TWO EQUATIONS FOR ELECTROMAGNETIC FIELD AND POPULATION INVERSION IN SOLID STATE LASER A66-16773

DEGREE OF EXCITATION OF METASTABLE STATE DETERMINED, USING LUMINESCENCE SATURATION PHENOMENON, CALCULATING POPULATION OF WORKING LEVEL OF LASER SUBSTANCE A66-22027

RUBY LASER AMPLIFIER AT LIQUID-NITROGEN TEMPERATURE TREATED AS THREE-MEDIUM TRANSMISSION SYSTEM, NOTING GAIN CHANGE WITH NEGATIVE ATTENUATION A66-22867

STEADY STATE VALUE OF INVERTED POPULATION, POWER OUTPUT, THRESHOLD BEHAVIOR AND SPIKING CHARACTERISTICS FOR SINGLE-MODE LASER WHEN RADIATION INTENSITY HAS SPATIAL DEPENDENCE A66-24562

POSITION INDICATOR  
OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER AS AIRCRAFT ALTIMETER TO ELIMINATE SPURIOUS ECHOES A65-32588

POTASSIUM BROMIDE  
U V RADIATION STIMULATED EMISSION IN OPTICALLY PUMPED POTASSIUM BROMIDE CRYSTALS USEFUL FOR LASER EMISSION WHICH IS CONSISTENT WITH POPULATION INVERSION EXCITON SCHEME A65-35069

POTASSIUM COMPOUND  
OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-15352

OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-20893

CRYSTAL GROWTH, LATTICE CONSTANT, AND DENSITY OF MAGNESIUM POTASSIUM FLUORIDE AND BARIUM ZIRCONATE AD-623511 N66-14467

POTENTIAL THEORY  
SELECTED FOREIGN SCIENTIFIC AND TECHNICAL LITERATURE ON POTENTIAL THEORY, SEMICONDUCTOR LASERS, COMPOSITE PROPELLANTS, AROMATIC, POLYESTERS, AND TECTONICS N66-21862

POWDERED METAL  
SPECTROSCOPIC INVESTIGATION OF LASER EXCITED

## POWER DENSITY

MOLECULAR SPECTRA FROM POWDERED SOLIDS FOR METEOR  
AND REENTRY PHYSICS A65-16382

## POWER DENSITY

POWER DENSITY IN NOISE SIDEBANDS OF LASER CAUSED  
BY EMISSION NOISE IN ACTIVE MEDIUM A65-15321

ATMOSPHERIC TURBULENCE, POWER FLUCTUATION AND  
RADAR DETECTION IN LASER SYSTEMS DESIGN A66-17294

## POWER EFFICIENCY

SINGLE MODE OUTSIDE DIFFERENTIAL QUANTUM  
EFFICIENCIES OF CIRCULAR AND RECTANGULAR LASER  
DIODES COMPARED A65-21321

HIGH QUANTUM EFFICIENCY IN NARROW BAND TRIVALENT  
RARE EARTH DOPED QUANTUM COUNTER ACHIEVED BY LASER  
PUMPING A65-27604

EXTERNAL POWER EFFICIENCY OF GALLIUM ARSENIDE  
LASER DIODES  
QPR-2 N65-32069

DIELECTRIC CAVITY MASER COMPOSED OF RUBY ROD  
SEPARATING METAL PLATES, NOTING STRENGTH  
SATURATION BEHAVIOR, POWER OUTPUT, ETC A66-21308

## POWER GAIN

GAIN NARROWING OF INHOMOGENEOUSLY BROADENED LINE  
IN STIMULATED EMISSION IN LASER AMPLIFIER A65-22615

LASER OSCILLATOR WITH EXTERNALLY APPLIED SIGNAL  
EMPHASIZING PUSHING-PULLING EFFECTS, POWER GAIN  
AND NATURAL OSCILLATION QUENCHING CONDITIONS A65-25861

LASER BEAM MULTIMODE EFFECTS AS HINDRANCE TO  
INTERPRETATION OF QUANTITATIVE MEASUREMENTS OF  
RAMAN GAIN A65-26958

TRAVELING WAVE MASER EMPLOYING MAGNETIC STAGGER  
TUNING IN SMALL COMPACT SUPERCONDUCTING MAGNET  
ACHIEVES TRADING EXCESS ELECTRONIC GAIN FOR  
BANDWIDTH A65-29196

CALCULATION OF RADIATION INTENSITY OBTAINED FROM  
LASER WITH HOMOGENEOUS LINE BROADENING GENERALIZED  
FOR ARBITRARILY LARGE LOSS FRACTION PER PASS A65-32219

GAS PRESSURE AND TUBE DIAMETER EFFECT ON OPTICAL  
GAIN OPERATING CHARACTERISTICS OF XENON LASER  
AMPLIFIER A65-32743

HELIUM-NEON LASER AMPLIFIER AS FUNCTION OF MIXTURE  
RATIO, GAS PRESSURE, INPUT SIGNAL LEVEL AND  
ELECTRICAL POWER INPUT TO AMPLIFIER TUBE A66-12206

GAIN AND BANDWIDTH NARROWING IN REGENERATIVE  
HELIUM-XENON LASER AMPLIFIER A66-12308

HIGH POWER BREWSTER WINDOW LASER WITH GAS FILLS,  
DISCUSSING POWER OUTPUT AND EFFICIENCY PARAMETERS A66-13983

GAIN MEASUREMENTS OF RAMAN AMPLIFIER PUMPED BY  
DIFFUSE RUBY RADIATION A66-16388

## PRASEODYMIUM

LASER OSCILLATION IN CALCIUM TUNGSTATE CRYSTALS  
ACTIVATED WITH TRIVALENT PRASEODYMIUM A66-14898

## PREAMPLIFIER

HELIUM-NEON LASER PREAMPLIFIER SYSTEM FOR VERY  
HIGH GAIN TRANSITION AT 3.39 MICRON WAVELENGTH A65-21335

## PRECIPITATION

EVALUATION OF MASER-EQUIPPED WEATHER RADAR SET AND  
AREA PRECIPITATION MEASUREMENT INDICATOR -  
METEOROLOGICAL SENSING DEVICE - ELECTRONICS  
QPR-1 N66-14191

## SUBJECT INDEX

MASER EQUIPPED WEATHER RADAR AND PRECIPITATION  
MEASUREMENT INDICATOR  
CPR-2 N66-19957

## PRESSURE EFFECT

EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR  
HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION A65-18558

EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR  
HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION A65-27151

PRESSURE DEPENDENCE OF OUTPUT OF HELIUM-NEON  
GASEOUS LASER IN HIGH PRESSURE RANGE A66-11375

WAVELENGTH CHANGE OF SPONTANEOUS AND STIMULATED  
EMISSION WITH UNIAXIAL PRESSURE UNDER CW  
OPERATION OF GA AS DIODE LASER AT 4 DEGREES K A66-19922

## PRESSURE MEASUREMENT

LASER PROPERTIES RELEVANT TO MEASUREMENT OF  
PHYSICAL PARAMETERS - MAPPING VIBRATING SURFACE,  
FREQUENCY RESPONSE OF TRANSDUCER, SENSITIVE  
LEVEL, PRESSURE DETERMINATION, AND HOLOGRAMS  
NASA-CR-68235 N66-12860

## PRINTER

USE OF OPTICAL MASERS IN DISPLAYS AND PRINTERS -  
DIGITAL ELECTRO-OPTIC LIGHT DEFLECTOR, CEMENTING  
OF CALCITE CRYSTALS, HIGH SPEED ELECTRONIC  
SWITCHES, AND BIREFRINGENT CRYSTALS  
REPT.-6 N65-13857

## PRISM

HIGH POWER LASER BEAM COLLINEARIZATION USING  
BIREFRINGENCE OF UNIAXIAL CALCITE CRYSTAL PRISM A65-25828

## PROBABILITY DENSITY

EXPERIMENTAL PROCEDURE TO MEASURE PROBABILITY  
DENSITY AMPLITUDE OF ELECTRIC COMPONENT OF LASER  
RADIATION FIELD A65-21070

EXPERIMENTAL PROCEDURE TO MEASURE PROBABILITY  
DENSITY AMPLITUDE OF ELECTRIC COMPONENT OF LASER  
RADIATION FIELD A65-31235

## PROPAGATION

EFFECTS OF PROPAGATION TIMES ON STEERING NARROW  
BEAM LASER FOR COMMUNICATIONS BETWEEN PLANETARY  
DEEP-SPACE VEHICLE AND EARTH GROUND STATION OR  
RELAY STATION - SPACIAL BEAM OFFSET  
NASA-TM-X-55306 N66-11202

## PROPAGATION MODE

ATMOSPHERIC EFFECTS ON LASER ENERGY PROPAGATION -  
LITERATURE SURVEY  
RE-TR-65-3 N65-23622

LASER CAVITY ANALYSIS, THRESHOLD MEASUREMENTS,  
FREQUENCY DISTRIBUTION, MODE DENSITY, AND  
SPIKING STRUCTURE  
AFCL-65-481 N65-32298

MEASUREMENTS AND LIMITATIONS OF ATMOSPHERIC  
EFFECTS ON LASER PROPAGATION FOR SPACE  
COMMUNICATION  
NASA-CR-67382 N65-35846

## PROPAGATION VELOCITY

PROPAGATION RATE OF HIGH POWER LASER LIGHT PULSE  
IN INVERSELY POPULATED MEDIUM A66-15333

## PROPULSION SYSTEM

LASER RESEARCH IN U.S.S.R., COMBUSTION  
INSTABILITY IN LIQUID ROCKET AND AIR BREATHING  
PROPULSION, GAS DYNAMICS AND PROPERTIES AT HIGH  
TEMPERATURE, AND MORPHOLOGICAL FORMS IN POLYMERS  
AD-460286 N65-23836

## PROTECTION

REAL TIME, PROJECTION DISPLAY SYSTEM USING LASER  
LIGHT SOURCE  
UI-903600-1 N65-35989

STUDIES ON RADIATION PROTECTION FOR MAN, OPTICAL

- MASER OF NEODYMIUM IN TUNGSTATE, CYLINDER WAVE PROPAGATION ANALYSIS, AND ELECTROMOTIVE FORCE OF INDIUM ANTIMONIDE COMPOUND  
JPRS-33152 N66-15042
- PROTECTIVE COATING  
FLUID MECHANICS, LUBRICATION, CORROSION, MASERS, BIOLOGICAL STRESS, PROTECTIVE COATINGS, NEUTRON ACTIVATION, FRACTOGRAPHY, METABOLISM, GUIDED MISSILE LAUNCHING, AND CATAPULTS  
AD-623630 N66-14468
- PROTON MASER  
LOW FREQUENCY MAGNETIC FIELD SENSOR - PROTON MASER ANTENNA DESIGN CONSTRUCTION AND PERFORMANCE  
RADC-TR-64-567 N65-32211
- PULSE AMPLITUDE  
LASER OSCILLATION FREQUENCY AND AMPLITUDE FLUCTUATIONS MEASURED BY DELAY LINE AND SQUARE LAW DETECTOR  
A65-20510
- INTERACTION BETWEEN OPTICAL MASER MEDIUM AND ELECTROMAGNETIC PULSE PROPAGATING IN IT, DISCUSSING AMPLIFIER EQUATIONS AND STEADY STATE PULSE / SSP / IN AND OUT OF RESONANCE  
A65-33374
- NONLINEAR AMPLIFICATION OF LIGHT PULSE PASSING THROUGH LASER OPERATING AT SATURATION REGIME  
A66-21963
- PULSE AMPLITUDE MODULATION /PAM/  
LASER GIANT PULSING USING SATURABLE ABSORBER INSIDE CAVITY AS FAST SWITCH  
A65-24960
- PULSE CODE MODULATION /PCM/  
LASER CURRENT-MONITORING DEVICE, SMALL CURRENT TRANSFORMER FEEDS SOLID-STATE PULSE-CODING DEVICE WHICH MODULATES GALLIUM-ARSENIDE LASER  
A65-29885
- PULSE DIFFRACTION  
POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR  
A65-36058
- POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR  
A66-15861
- PULSE DURATION MODULATION /PDM/  
OUTPUT POWER AND PULSE DURATION OF RUBY LASER  
A66-12602
- LASER RANGING VIA DIGITAL COUNTER COUPLED PHOTOMULTIPLIER TUBE, NOTING SPECTRAL RESPONSE, GAIN TRANSIT TIME DEPENDENCE, OUTPUT COUPLING AND EFFECTIVE CATHODE DIAMETER  
A66-23759
- PULSE MODULATION  
HELIUM-NEON LASER MODULATION BY POSITIVE AND NEGATIVE VOLTAGE PULSES  
A65-35931
- PULSE TIME MODULATION /PTM/  
COHERENCE THEORY FOR COLLIMATION AND FOCUSING OF TIME-AVERAGED INTENSITY OF PULSED MULTIMODE LASER RADIATION  
A66-12205
- PULSE TRANSMISSION SYSTEM  
DATA PULSED TRANSMISSION OVER ELECTRON-INJECTION LASER COMMUNICATION SYSTEM, USING CONTINUOUS WAVES  
A66-19934
- OPTICALLY BIASED PULSED TRANSMISSION MODE OPERATION OF Q-SWITCHED LASER, IN CONNECTION WITH KERR CELLS INHIBITING LASING ACTION  
A66-19937
- PULSE WIDTH  
LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION  
A65-35875
- LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION  
A66-18970
- PULSED GENERATOR  
LASER OPERATION AS PULSED REGENERATIVE OSCILLATOR
- ARISING FROM MODE COUPLING DUE TO TIME-VARYING LOSS IN CAVITY OR NONLINEAR CHARACTERISTICS OF INVERTED POPULATION  
A65-27603
- COMPACT PULSE GENERATOR FOR DRIVING GALLIUM ARSENIDE LASERS AT ROOM TEMPERATURE  
N65-20175
- SEMICONDUCTOR-BASED PULSE GENERATOR FOR LASER EXCITATION  
A66-11042
- SEMICONDUCTOR-BASED PULSE GENERATOR FOR LASER EXCITATION  
A66-23289
- PULSED LASER  
SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF PULSED RUBY LASER OUTPUT  
A65-14131
- RADIATION FLUCTUATIONS IN LASER PULSE REGIME, DISCUSSING ERRORS ARISING IN COMPARING BASIC WITH SECONDARY EMISSION  
A65-14617
- PARAMETRIC DEPENDENCE OF TIME PROFILE, PEAK POWER AND NUMBER OF GIANT PULSES OF ROTATING PRISM Q-SWITCHED LASERS  
A65-15103
- CIRCUITRY, MECHANICAL CONSTRUCTION AND PRELIMINARY PERFORMANCE OF GALLIUM ARSENIDE LASER TRANSMITTER OPERATED AT ROOM TEMPERATURE  
A65-15327
- SINGLE PULSES OF ELECTRON EMISSION PRODUCED BY SPINNING-PRISM Q-SWITCHED RUBY LASER  
A65-15443
- NANOSECOND HEATING OF AQUEOUS SYSTEMS BY Q-SWITCHING ROTATING PRISM RUBY LASER  
A65-15708
- OPTIMUM PEAK POWER FROM GIANT PULSE LASER IN TERMS OF LOSS FACTOR AND POPULATION DENSITY  
A65-15824
- BACKGROUND GAS PRESSURE EFFECT ON LASER INDUCED ELECTRON EMISSION FROM ZINC AND TANTALUM SURFACES  
A65-15838
- PULSED RUBY LASER ROD CAVITY LOSS MEASUREMENTS FROM 77 TO 293 DEGREES K INDICATING ESSENTIALLY CONSTANT LOSS  
A65-16129
- OPTICAL PUMP PULSE SHAPE EFFECT ON POPULATION INVERSION ATTAINED IN RUBY LASER  
A65-16569
- BROADBAND DIELECTRIC MIRRORS USED WITH PULSED GAS LASER TO OBSERVE LASER OSCILLATIONS IN VISIBLE WAVELENGTH REGION  
A65-16570
- GAIN DELAY CHARACTERISTICS OF FOUR-LEVEL NEODYMIUM-DOPED PULSED GLASS-LASER OSCILLATOR-POWER AMPLIFIER CHAIN  
A65-16574
- QUASI-CONTINUOUS OPERATION OF CALCIUM TUNGSTATE/NEODYMIUM ION MASER USING LONG DURATION PUMPING PULSES  
A65-16575
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING TOTAL REFLECTION PRISM  
A65-18462
- GIANT PULSE LASER APPLIED TO NONLINEAR OPTICAL EFFECT OF STIMULATED RAMAN SCATTERING WITH REFERENCE TO EMISSION ANGLE MEASUREMENT TECHNIQUE  
A65-19996
- SEMICONDUCTOR PULSE MASER BASED ON THEORY OF EXISTENCE OF ELECTRODIPOLE TRANSITIONS WITH SPIN ORIENTATION SHIFTS  
A65-20909
- RADIATIVE REACTION EFFECTS ON GIANT PULSE LASER STABILITY IN ANISOTROPIC MEDIUM  
A65-20913
- SUPPRESSING PULSED LASER SPIKING BY PROVIDING EQUILIBRIUM PHOTON DENSITY AS THRESHOLD IS REACHED, NOTING CASE OF RUBY LASER  
A65-21300
- PROCESSING EVAPORATED CADMIUM SULFIDE THIN FILMS TO ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING

- LASER-INDUCED ELASTIC VIBRATIONS  
A65-21875
- PULSED LASER DOSIMETER THAT MEASURES DANGER LEVEL OF RADIATION OF DIRECT OR REFLECTED BEAMS AS SAFEGUARD TO EYE DAMAGE  
A65-21951
- PULSED WATER VAPOR LASER FOR FAR IR GIVING DESIGN AND PERFORMANCE  
A65-22626
- LASER PULSE GENERATION WITH PLASMA RESULTING FROM DISCHARGE IN HYDROGEN AS MEDIUM  
A65-22728
- LASER OSCILLATION IN PULSED NOBLE-GAS-ION LASER AT NEAR-IR  
A65-22785
- RATE EQUATION SOLUTIONS FOR Q-SPOILED AND PULSED TRANSMISSION MODE / PTM/ OPERATION OF THREE-LEVEL LASER  
A65-22933
- LASER TYPES AND THEIR APPLICATION IN RADAR, INSTRUMENTATION, NAVIGATION AND COMMUNICATIONS  
A65-24131
- SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF PULSED RUBY LASER OUTPUT  
A65-24951
- PUMPING POWER FORMULA FOR DETERMINING CHARACTERISTICS OF CONTINUOUS WAVE AND PULSED LASERS  
A65-26687
- OPTICAL AMPLIFICATION OF APPARENT RATE OF REFLECTOR ROTATION IN Q-SWITCHING OF LASER RESONATOR  
A65-26946
- NINE ADDITIONAL LASER LINES IN PULSED XENON DISCHARGE UNDER CONDITIONS THAT DO NOT PRODUCE PREVIOUSLY OBSERVED LINES  
A65-26953
- GIANT LASER EMISSION PULSES IN NEODYMIUM ACTIVATED GLASS ROD BY VARYING CAVITY Q WITH QUINOLINE SOLUTION OF POLYMETHINE DYE  
A65-27554
- MODEL DESCRIPTION AND MATHEMATICAL FORMULATION FOR SPIKE PULSING PHENOMENON OBSERVED IN OPTICALLY PUMPED THREE-LEVEL LASERS  
A65-27607
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING TOTAL REFLECTION PRISM  
A65-28091
- GALLIUM ARSENIDE LASER DIODES BEHAVIOR AT HIGH PULSE RADIATION LOADS  
A65-29356
- STABILITY OF CORRECTED COUPLED-MODE LASER EQUATION DERIVED FROM MODEL FOR RUBY LASER SPIKING RESULTING FROM MODE INTERFERENCE  
A65-29805
- NATURAL SELECTION OF MODES USING PASSIVE Q-SWITCH IN GIANT PULSE RUBY LASER WHICH NARROWS OUTPUT SPECTRUM  
A65-29850
- SINGLE AXIAL MODE OPERATION OF RUBY LASER AT ROOM TEMPERATURE, USING SATURABLE FILTER Q-SWITCH AND RESONANT REFLECTOR  
A65-29852
- LASER CURRENT-MONITORING DEVICE, SMALL CURRENT TRANSFORMER FEEDS SOLID-STATE PULSE-CODING DEVICE WHICH MODULATES GALLIUM-ARSENIDE LASER  
A65-29885
- DENSE HIGH-TEMPERATURE HYDROGEN PLASMA PRODUCTION BY INTENSE LASER PULSE HEATING OF MAGNETICALLY CONTAINED PLASMA  
A65-29978
- LIGHT DETECTION AND RANGING / LIDAR/ TECHNIQUE USE IN ATMOSPHERIC RESEARCH, PARTICULARLY METEOROLOGICAL FACTORS IMPORTANT TO AVIATION AND ROCKET OPERATIONS  
AIAA PAPER 65-464  
A65-30204
- SILICON CONTROL RECTIFIER LONG PULSE DRIVER FOR INJECTION LASERS  
A65-30330
- LONGITUDINAL MODE SELECTION IN GIANT PULSE LASER RESULTING IN SINGLE-MODE OUTPUT  
A65-30345
- NOISE IN GAS LASERS AND LASER DETECTORS, AMPLIFIERS AND OSCILLATORS, NOTING HELIUM-NEON LASER OSCILLATION  
A65-31002
- LASER PULSE-SHAPING AND MODE-LOCKING WITH TRAVELING AND STATIONARY ACOUSTIC WAVES IN ARGON LASER  
A65-31763
- LASER RADIATION EFFECTS AND APPLICATION NOTING POWER OUTPUT, MELTING, VAPORIZATION AND SURFACE EMISSION  
A65-31764
- PLASMA DECAY IN PULSE DISCHARGE OF HELIUM-NEON LASER GRAPHICALLY DEPICTED UNDER CONDITIONS OF GENERATION  
A65-31878
- OBSERVED AND PREDICTED EFFICIENCY OF CONVERSION OF RADIATION FROM GIANT PULSE RUBY LASER INTO STIMULATED RAMAN SCATTERING  
A65-32209
- GAS EFFECTS PRODUCED BY PULSED LASER BEAM IN BALLISTIC TORSIONAL PENDULUM PHOTOMETER, NOTING DEFLECTION DUE TO PHOTON MOMENTUM EXCHANGE  
A65-32229
- ZEEMAN EFFECT IN PARAMAGNETIC CRYSTALS BY RUBY FOR MICROWAVE MODULATION OF PULSED LASER BY ABSORPTION  
A65-32746
- LASER OSCILLATION IN VISIBLE SPECTRA OF SINGLY IONIZED ZINC AND CADMIUM OBTAINED WITH PULSED DISCHARGES IN HEATED VAPORS OF THESE METALS MIXED WITH NOBLE GASES  
A65-32747
- PULSED MOLECULAR NITROGEN LASER THEORY VIA ELECTRON IMPACT EXCITATION OF TRIPLET STATES  
A65-33050
- LASER OSCILLATION IN VISIBLE REGION FROM PULSED COLD CATHODE DISCHARGE IN IONIZED S AND P  
A65-33379
- PULSE-DISCHARGE PLASMA DECAY STUDIED BY OBSERVATION OF GENERATION PROCESSES IN HELIUM-NEON PULSE LASER  
A65-33584
- WHITE LIGHT EMISSION WHEN PULSED LASER BEAM FOCUSES ON TARGETS IS MAINLY DUE TO TEMPERATURE RADIATION  
A65-34957
- ACTIVE AND PASSIVE Q-SWITCHES FOR INCREASING STORED PUMPING ENERGY OF LASERS AND INHIBITING RESONANCE FOR SUBSEQUENT PEAK LASER EXCITATION AND DISCHARGE  
A65-35118
- POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR  
A65-36058
- VISIBLE DISCHARGES INDUCED IN GASES BY FOCUSED RUBY LASER PULSES  
REPT.-1579-14  
N65-14982
- NANOCSECOND HEATING OF AQUEOUS SYSTEMS BY GIANT LASER PULSES AND REDUCTION OF LIGHT ABSORPTION AT HIGH LASER POWER DENSITIES  
AD-451466  
N65-16471
- PULSED GAS LASER FOR FAR INFRARED REGION OF SPECTRUM  
N65-20170
- FOCUSING AND COLLIMATION PROPERTIES OF PULSED MULTIMODING RUBY LASER  
REPT.-1579-19  
N65-21554
- BREAKDOWN OF ARGON BY NEODYMIUM AND RUBY LASER PULSES  
REPT.-1935-1  
N65-22072
- SPECTRAL LINE WIDTH NARROWING OF PULSED TRAVELING WAVE RUBY LASER OUTPUT  
AD-610865  
N65-22139
- MATERIAL VAPORIZATION BY Q-SPOILED LASER PULSES FOR SPECTROSCOPIC ANALYSIS OF VAPOR OPTICAL EMISSION AND ABSORPTION PROPERTIES  
AFCL-64-871  
N65-22274
- PHOTOCHEMICAL BEHAVIOR OF METAL PHTHALOCYANINES

# SUBJECT INDEX

# PULSED LASER CONT

## IN PRODUCING GIANT PULSES FROM RUBY LASER

N65-23435

CONTINUOUSLY PULSED LASER DEVICE WITH SELF-CONTAINED LASER OSCILLATOR AND POWER SUPPLY - LASER HEADS USING TUNGSTEN LAMPS AND XENON FLASHLAMPS FOR PUMP EXCITATION  
REPT.-2

N65-27581

PULSED XENON FLASHLAMP AND CONTINUOUS INCANDESCENT TUNGSTEN LAMP TRADEOFFS AS NEODYMIUM-YTTRIUM ALUMINUM GARNET CRYSTAL LASER PUMPS  
REPT.-3

N65-30242

GIANT PULSES FROM NEODYMIUM-DOPED GLASS LASER WITH PHOTSENSITIVE LIQUID Q-SWITCH

N65-34081

STORAGE DIODE LASER RESEARCH  
AD-618297

N65-34108

PULSED LASER FOR SIMULATING TANK GUN FIRING FOR TRAINING OF TANK GUNNERS  
NAVTRADEVCE-1311-1

N65-34674

INSTRUMENTATION SYSTEM FOR MEASUREMENT OF PULSED LASER OUTPUT - CALORIMETER AND INTEGRATOR  
WL-TR-64-127

N65-34706

PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER

A66-10262

DESTRUCTIVE AND LUMINESCENCE EFFECTS OF FOCUSED RUBY LASER BEAM ON RUBY

A66-10265

PEAK POWER TRANSIENTS OF NEAR CONFOCAL HELIUM-NEON LASER WORKING AT 6328 ANGSTROMS ON PULSED DISCHARGE BASIS

A66-10329

SELF-LOCKED GAS LASER MODE DEPENDENCE ON CAVITY LENGTH AND POSITION OF LASER MEDIUM IN CAVITY

A66-10347

LASER ACTION AT 5401 ANGSTROMS IN PURE NEON PULSED HIGH VOLTAGE DISCHARGE

A66-10353

CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION

A66-11188

PRESSURE DEPENDENCE OF OUTPUT OF HELIUM-NEON GASEOUS LASER IN HIGH PRESSURE RANGE

A66-11375

NONLINEAR PROPAGATION OF PULSE SIGNAL IN LASER TYPE TRAVELING WAVE AMPLIFIER

A66-11841

PERIODIC AUTOMODULATION OF RADIATION AND POSSIBILITY OF GENERATING GIANT PULSES IN THREE-LEVEL LASER WITH INHOMOGENEOUSLY EXCITED ACTIVE MEDIUM

A66-11842

COHERENCE THEORY FOR COLLIMATION AND FOCUSING OF TIME-AVERAGED INTENSITY OF PULSED MULTIMODE LASER RADIATION

A66-12205

MODE-CONTROLLED GIANT PULSE LASER USED TO PRODUCE TWO-BEAM HOLOGRAM IN SHORT EXPOSURE TIME OF 30 NSEC

A66-12215

PULSED LASER-CREATED PLASMAS BY LIGHT ABSORPTION BY SKIN EFFECT

A66-12975

PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER

A66-13307

DESTRUCTIVE AND LUMINESCENCE EFFECTS OF FOCUSED RUBY LASER BEAM ON RUBY

A66-13310

MEASURING DEVICE FOR PULSED LASER OUTPUT POWER USING BOLOMETER, AMPLIFIER AND OSCILLOSCOPE

A66-13888

TIME CHARACTERISTICS IN GENERATION OF GIANT LASER PULSE STUDIED BY CIRCUIT WITH PRISMATIC SHUTTERS

A66-13889

LASER OSCILLATIONS AND SELF Q-SWITCHING,

DISCUSSING PULSED FLASH-LAMP EXCITATION EXPERIMENTS WITH TRIPLY ACTIVATED CONFOCAL BARIUM CROWN GLASS ETALON

A66-13980

STIMULATED BRILLOUIN AND RAMAN SCATTERING IN GASES, DISCUSSING SOUND VELOCITY CALCULATION FROM FREQUENCY SHIFT AND ARGON, HYDROGEN AND NITROGEN

A66-13981

RISE TIME AND OUTPUT POWER OF SINGLE PULSE IN HELIUM LASER MEASURED BY METHOD OF CHANGING Q-FACTOR BY PLATE LOCATED IN RESONANT CAVITY

A66-14332

INTERACTION OF LIGHT PULSE FROM RUBY LASER WITH MERCURY SURFACE, OBSERVING MECHANICAL IMPACT BELIEVED TO BE RAPID VAPORIZATION PROCESS

A66-14373

PLASMA GENERATION BY FOCUSING LASER BEAM IN AIR AT ATMOSPHERIC PRESSURE AND ROOM TEMPERATURE INDICATE CONNECTION WITH LUMINOUS ENERGY ABSORPTION DURING BREAKDOWN

A66-14538

SHIFT OF EMISSION SPECTRUM IN PULSED GAS LASER, NOTING WAVEFORM CHARACTERISTICS

A66-14974

PROPAGATION RATE OF HIGH POWER LASER LIGHT PULSE IN INVERSELY POPULATED MEDIUM

A66-15333

POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR

A66-15861

PUMPING POWER FORMULA FOR DETERMINING CHARACTERISTICS OF CONTINUOUS WAVE AND PULSED LASERS

A66-15900

SEARCH VIA LASER RECEIVERS FOR INTERSTELLAR COMMUNICATIONS

A66-16669

REGULAR PERIODIC SPIKING IN OUTPUT OF PULSED NEODYMIUM DOPED BORATE GLASS LASER AT PUMPING LEVELS SLIGHTLY ABOVE THRESHOLD

A66-16672

LASER ACTION ON FIVE GREEN LINES AND SIX IR LINES CAUSED BY PULSING MANGANESE DISCHARGE OF COLLISION LASER IN ATOMIC VAPOR OF NEUTRAL MANGANESE

A66-16763

PULSED LASER WELDING, WIRE-TO-WIRE, SHEET-TO-SHEET, CIRCUIT BOARD, VACUUM TUBE, ETC

A66-18153

DECAY OF F-CENTER EXCITATIONS IN ALKALI HALIDES INDUCED BY SHORT INTENSE PULSE OF Q-SWITCHED RUBY LASER

A66-19367

ACCURATE TRACKING OF BEACON- EXPLORER ORBITING OPTICAL REFLECTORS, USING PULSED RUBY LASER BEAMS

A66-19902

TIME DEPENDENT EMISSION BEHAVIOR OF SINGLE AXIAL MODE OF DIFFRACTION LIMITED RUBY LASER AT ROOM TEMPERATURE

A66-20420

ROOM TEMPERATURE QUASI-CONTINUOUSLY PUMPED RUBY GIANT PULSE LASER WITH SATURABLE ABSORBER Q-SWITCH

A66-21248

SPONTANEOUS EMISSION NOISE PROPERTIES OF PAIR OF PULSED RUBY LASER AMPLIFIERS

A66-21310

ELECTRON AND ION EMISSION FROM PULSED RUBY LASER ILLUMINATED METALLIC SURFACE INTO VACUUM, DETERMINING APPLICATION TO PULSED ION THRUSTOR

A66-21453

LASER SIMULATED NUCLEATION IN BUBBLE CHAMBER, COMPARING SENSITIVITY WITH RADIOACTIVELY STIMULATED NUCLEATION

A66-21583

NONLINEAR AMPLIFICATION OF LIGHT PULSE PASSING THROUGH LASER OPERATING AT SATURATION REGIME

A66-21963

TEXT ON HIGH SPEED OPTICAL PULSE TECHNOLOGY,



- LASERS AND MEASURING TECHNIQUES, EMPHASIZING CAPACITOR DISCHARGE APPLICATION A66-22063
- STANDING WAVES IN LASER RESONATORS VERIFIED BY PLACING THIN METALLIC FILMS BETWEEN EXTERNAL MIRRORS OF PULSED NEODYMIUM LASER A66-22893
- GADOLINIUM MOLYBDENATE AS FERROELECTRIC HOST IN PULSED LASER, NOTING LIGHT MODULATION AND CRYSTAL DOMAIN A66-23207
- GAS SPECTROSCOPY OF LASER-INDUCED STIMULATED BRILLOUIN EFFECT IN HIGH PRESSURE OXYGEN A66-23432
- SINGLE PULSE OPERATION OF LASERS, NOTING ENERGY STORAGE AND AMPLIFICATION EFFECT FOR FOUR- AND THREE-LEVEL ACTIVE MEDIUM A66-23667
- PULSE EXCITATION OF VOLUME OF GAS TO COHERENTLY RADIATING STATE APPLIED TO BEAM MASER SPECTROMETER A66-23731
- CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION A66-24009
- LASER WELDING FOR PRODUCTION MICROWELDING, NOTING DESIGN, CONSTRUCTION AND APPLICATION ASTM PREPRINT MM66-707 A66-24415
- STEADY STATE VALUE OF INVERTED POPULATION, POWER OUTPUT, THRESHOLD BEHAVIOR AND SPIKING CHARACTERISTICS FOR SINGLE-MODE LASER WHEN RADIATION INTENSITY HAS SPATIAL DEPENDENCE A66-24562
- PULSED INDUCED EMISSION IN HYDROGEN BEAM LASER FOR CASE OF TWO RELAXATION TIMES, DETERMINING POLARIZATION ONLY BY NUMBER OF ACTIVE PARTICLES IN RESONATOR A66-24884
- GAS DISCHARGE BY LASER PULSE, TAKING INTO ACCOUNT PHOTOIONIZATION DUE TO ELECTRON IMPACT A66-24887
- TREATMENT OF STEEL WITH LASER BEAM, OBTAINING PRECISION HOLES WITHOUT AFFECTING MICROHARDNESS OF METAL A66-24898
- GROWTH OF WAVES IN PULSED LASER AMPLIFIER CALCULATED USING QUASI ONE-DIMENSIONAL MODEL - AMPLIFICATION OF EXTERNALLY IMPRESSED AND SPONTANEOUSLY EMITTED WAVES AVCO-EVERETT RES. REPT.-233 N66-10972
- PULSED LASER OSCILLATOR - ADVANCED DEVELOPMENT MODEL ECOM-00326-4 N66-12398
- USE OF LASER BEAM IN SPECTROGRAPHIC ANALYSIS - NORMAL LASER AND GIANT SPIKE LASER AFCRL-65-586 N66-12799
- PULSED YTTRIUM-ALUMINUM GARNET NEODYMIUM LASER DEVICE - SOLID STATE LASER DEVICE QPR-9 N66-14725
- POWER AND PATH LENGTH EFFECTS ON STIMULATED RAMAN SPECTRA IN METHANE AND HYDROGEN STUDIES USING GIANT PULSED LASER N66-20037
- PULSED RADIATION**
- MASER PEAK PULSE CHARACTERISTICS DURING INSTANTANEOUS SWITCHING OF INTERFEROMETER WHEN LOSS FACTOR RAPIDLY DECREASES A65-23004
- GIANT RUBY LASER PULSE PRODUCTION FROM RAPID SATURATION OF DYE ABSORBER SOLUTION IN OPTICAL CAVITY BY SINGLET-SINGLET TRANSITIONS A65-33521
- RADIATION PULSES FROM RUBY OPTICAL QUANTUM GENERATOR DURING SINGLE IGNITION FTD-TT-65-134/162 N65-33409
- SOLID-STATE LASER SYSTEM AS RADIATION PULSE GENERATOR
- STL-4127-6004-SU-000 N65-33686
- SIGNAL VELOCITY OF MASERS, AND MICROWAVE PHONON ATTENUATION AND PULSED HEAT RADIATION IN SINGLE CRYSTAL SEMICONDUCTORS REPT.-8 N65-36734
- CUT-OFF OF RUBY LASER EMISSION BY PULSED ELECTRON AND BREMSSTRAHLUNG RADIATION, USING ADIABATIC TEMPERATURE A66-12447
- PHOTON ECHO, SHORT PULSE OF LIGHT SPONTANEOUSLY EMITTED BY DILUTE RUBY CRYSTAL AFTER RUBY-LASER PULSE IRRADIATION A66-18442
- LASER DEVELOPMENT, DISCUSSING BASIC THEORY, PUMPING METHODS AND LASER TYPES A66-18700
- PUMP**
- FAST HIGH RADIANCE ABLATING LASER PUMP AND ENERGY STORAGE TECHNIQUE AFAL-TR-65-22 N65-22702
- PUMPING**
- SHOCK TUBE LASER PUMPING - FOUR COMBINATIONS OF LASER CRYSTAL AND PUMPING CONFIGURATION U-3104 N65-28154
- LASER RESEARCH DEALING WITH EFFECT OF PUMPING ON RUBY QUALITY, LANTHANUM FLUORIDE EXAMINATION, LARGE RUBY LASER RODS, DC OPERATION OF MERCURY TUBE, HOLOGRAMS, AND LASER PHYSICS NRL-MR-1604 N65-28920
- LASER ACTION BY ELECTRON BEAM PUMPING - LITERATURE SURVEY NOLTR-65-95 N65-33401
- OPTIMUM DESIGN OF HIGH PRESSURE, LARGE DIAMETER, DIRECT NUCLEAR PUMPED, GAS LASERS ANL-7030 N66-11926
- CHEMICAL PUMPING OF LASERS - EYE DAMAGE IN MONKEYS FROM LASER IRRADIATION U-3259 N66-13799
- PURIFICATION**
- RESEARCH IN CHINESE PEOPLES REPUBLIC - SOLAR FLUX, GAS DISCHARGE TUBE, NEODYMIUM LASER, GEOLOGICAL MECHANICS, MICROCRYSTALLINE GLASS, LOCATING OF THUNDER, AND PURIFICATION WITH DISTILLATION METHODS JPRS-33759 N66-16806
- Q**
- Q-FACTOR**
- MAGNETIC Q-FACTOR DESCRIBING ELECTROMAGNETIC FIELD ENERGY LOSSES IN PARAMAGNETIC MASER CRYSTALS A65-26860
- EFFECTS OF RESONATOR LENGTH AND MIRROR TRANSPARENCY AND ALIGNMENT UPON DYNAMIC AND STATIC CHARACTERISTICS OF RUBY LASER WITH MODULATED Q-FACTOR A65-35786
- ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION IN NEODYMIUM GLASS LASER A65-36826
- ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION IN NEODYMIUM GLASS LASER A66-13431
- LASER REGIME WITH GIANT PULSES GENERATED IN LYSOPROSIUM DOPED CADMIUM FLUORIDE UNDER CONTINUOUS PUMPING BY XENON LAMPS, OBTAINING Q FACTOR MODULATION BY ROTATING PRISM A66-19376
- Q-SPOILING**
- PARAMETRIC DEPENDENCE OF TIME PROFILE, PEAK POWER AND NUMBER OF GIANT PULSES OF ROTATING PRISM Q-SWITCHED LASERS A65-15103
- OUTPUT FREQUENCY QUADRUPLING IN Q-SPOILED NEODYMIUM-IN-GLASS LASER, USING NONLINEAR OPTIC EFFECT A65-15858
- RUBY LASER AMPLIFIER ENERGY INPUT-OUTPUT MATHEMATICAL ANALYSIS AND EXPERIMENTAL

# SUBJECT INDEX

# QUANTUM GENERATOR

- VERIFICATION A65-17648
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING TOTAL REFLECTION PRISM A65-18462
- REFLECTED RADIATION OF Q-SPOILED RUBY LASER FROM EXPLORER XXII A65-21306
- RATE EQUATION SOLUTIONS FOR Q-SPOILED AND PULSED TRANSMISSION MODE / PTM/ OPERATION OF THREE-LEVEL LASER A65-22933
- MASER PEAK PULSE CHARACTERISTICS DURING INSTANTANEOUS SWITCHING OF INTERFEROMETER WHEN LOSS FACTOR RAPIDLY DECREASES A65-23004
- LASER GIANT PULSING USING SATURABLE ABSORBER INSIDE CAVITY AS FAST SWITCH A65-24960
- COHERENT HIGH POWER PULSES FROM OPTICALLY PUMPED Y A G- ND LASER BY Q-SWITCHING FROM MIRROR ROTATION A65-26003
- OPTICAL AMPLIFICATION OF APPARENT RATE OF REFLECTOR ROTATION IN Q-SWITCHING OF LASER RESONATOR A65-26946
- Q-SWITCHING OF ND LASER USING POLYMETHINE DYE IN METHYL ALCOHOL SOLVENT A65-27533
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING TOTAL REFLECTION PRISM A65-28091
- NATURAL SELECTION OF MODES USING PASSIVE Q-SWITCH IN GIANT PULSE RUBY LASER WHICH NARROWS OUTPUT SPECTRUM A65-29850
- SINGLE AXIAL MODE OPERATION OF RUBY LASER AT ROOM TEMPERATURE, USING SATURABLE FILTER Q-SWITCH AND RESONANT REFLECTOR A65-29852
- Q-SWITCHING APPLIED TO SLOW SWITCHING AND PULSE SHAPING FOR SOLID STATE LASERS AIAA PAPER 65-343 A65-30797
- PHOTOGRAPHIC STUDY OF Q-SWITCHED LASER BEAM PROPAGATING OVER 10-MILE PATH A65-31044
- LASER CONFIGURATIONS, PERFORMANCE FEATURES AND LIMITATIONS DISCUSSING HE- NE, ION AND SOLID STATE LASERS A65-31881
- SIMULTANEOUS LASER OSCILLATION OBSERVED AT 6943 AND 6929 ANGSTROM WAVELENGTHS IN NORMAL AND Q-SPOILED OPERATION OF RUBY LASER A65-32748
- Q-SPOILED RUBY LASER BEAM FOCUSED ON GRAPHITE, OBTAINING SWAN EMISSION OF CARBON MOLECULE A65-34207
- MODE LOCKING EFFECTS IN INTERNALLY KDP MODULATED RUBY LASER A65-35063
- ACTIVE AND PASSIVE Q-SWITCHES FOR INCREASING STORED PUMPING ENERGY OF LASERS AND INHIBITING RESONANCE FOR SUBSEQUENT PEAK LASER EXCITATION AND DISCHARGE A65-35118
- MATERIAL VAPORIZATION BY Q-SPOILED LASER PULSES FOR SPECTROSCOPIC ANALYSIS OF VAPOR OPTICAL EMISSION AND ABSORPTION PROPERTIES AFCL-64-871 N65-22274
- PHOTOGRAPHIC FILM USED FOR QUANTITATIVE MEASUREMENTS OF INTENSITY DISTRIBUTION IN Q-SWITCHED LASER BEAM A66-14920
- MODE COMPETITION AND COUPLING IN Q-SWITCHED RUBY LASER A66-16383
- LIFE PERFORMANCE CHARACTERISTICS OF UNCOATED RUBY LASER Q-SWITCHED BY ROTATING PRISM FORMING END REFLECTOR OF LASER RESONATOR A66-16675
- Q-SWITCHED OPTICAL MASER SYNCHRONIZATION, DISCUSSING EXPERIMENTAL DESIGN, SETUP AND PERFORMANCE A66-17297
- ROOM TEMPERATURE QUASI-CONTINUOUSLY PUMPED RUBY GIANT PULSE LASER WITH SATURABLE ABSORBER Q-SWITCH A66-21248
- C-SWITCHING OF CARBON DIOXIDE AND NITROUS OXIDE GAS LASER TRANSITIONS A66-23354
- VIBRATIONAL AND ROTATIONAL RELAXATIONS IN CARBON DIOXIDE AND NITROUS OXIDE LASER SYSTEMS, USING Q-SWITCHING TECHNIQUES A66-23355
- QUANTUM AMPLIFIER
- MASER AMPLIFIER WITH COUPLED ACTIVE RESONATORS OPERATING AT 21 CM WAVELENGTH, NOTING ADVANTAGE OVER PASSIVE INPUT CIRCUIT A65-14136
- MASER APPLICATIONS AS RADIO RECEIVERS, DISCUSSING MULTIRESONATOR ALL-PASS QUANTUM AMPLIFIERS A65-16282
- MASER AMPLIFIER WITH COUPLED ACTIVE RESONATORS OPERATING AT 21 CM WAVELENGTH, NOTING ADVANTAGE OVER PASSIVE INPUT CIRCUIT A65-24011
- TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN 8-CM BAND A65-24882
- MASER APPLICATIONS AS RADIO RECEIVERS, DISCUSSING MULTIRESONATOR ALL-PASS QUANTUM AMPLIFIERS A65-25785
- QUANTUM STATISTICAL PROCEDURE DEVELOPED FOR RADIATION FIELD AND APPLIED TO LASER AMPLIFIERS A65-32707
- TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN 8-CM BAND A65-36359
- ZERO FIELD X-BAND MASER DESIGN FOR MICROWAVE QUANTUM AMPLIFIERS - MILLIMETER AND SUBMILLIMETER WAVE DEVICES REPT.-490F N65-25851
- MILLIMETER AND SUBMILLIMETER MASER DEVICES - IRON-DOPED MASER AMPLIFIER, PUSH-PULL RUTILE MASER, AND X-BAND ZERO FIELD MASERS REPT.-490H N66-16210
- QUANTUM COUNTER
- HIGH QUANTUM EFFICIENCY IN NARROW BAND TRIVALENT RARE EARTH DOPED QUANTUM COUNTER ACHIEVED BY LASER PUMPING A65-27604
- QUANTUM ELECTRODYNAMICS
- ACCURATE LOCATION OF OBJECT IN SPACE AND TIME AND CORRECTION OF MOVEMENTS BY USE OF QUANTUM ELECTRODYNAMICS A65-25036
- QUANTUM ELECTRODYNAMICS IN OPTICAL RESONATORS AND MASERS, THERMAL PINCHING, N-TYPE SEMICONDUCTORS, COHERENT LIGHT, TRANSISTOR SWITCHING, POPULATION INVERSION, AND BREAKDOWN AFOSR-65-0248 N65-23491
- QUANTUM STATISTICS FOR ANALYZING RADIATION FIELDS INTERACTING WITH OTHER SYSTEMS APPLIED TO MODEL LASER OPERATING AS LINEAR AMPLIFIER A66-13260
- QUANTUM GENERATOR
- MASERS AND LASERS, DISCUSSING COHERENT RADIATION BY ATOMS AND MOLECULES AND QUANTUM ELECTRONICS TECHNIQUES OF GENERATING ACOUSTIC OR ELECTROMAGNETIC SPECTRUM A65-31383
- GENERATION OF LIGHT USING SEMICONDUCTOR QUANTUM GENERATORS - SOLID STATE LASERS FTD-TT-65-337/164 N65-32851
- RADIATION PULSES FROM RUBY OPTICAL QUANTUM GENERATOR DURING SINGLE IGNITION FTD-TT-65-134/162 N65-33409
- BALANCED MIXER ACTION FOR OPTICAL HETERODYNING, USING MAGIC- T OPTICAL MIXER A66-24153

## QUANTUM MECHANICS

OPTICAL MASER THEORY INCLUDING OSCILLATORS,  
RADIATION EMISSION, QUANTUM MECHANICS, ETC  
A65-24004

QUANTUM ELECTRONICS HISTORICAL REVIEW COVERING  
DIFFICULTIES ENCOUNTERED IN LASER/MASER  
CONSTRUCTION A65-25256

QUANTUM MECHANICS OF SIGNALS AND NOISE IN  
ATTENUATORS AND MASER AMPLIFIERS, RELATING  
EXPECTATION VALUES AND THERMAL STATE OF SYSTEM  
A65-30510

MASTER EQUATION FOR COMPLETE STATISTICAL OPERATOR  
OF SOLID STATE LASER ACCORDING TO QUANTUM  
MECHANICS A65-31773

QUANTUM STATISTICAL PROCEDURE DEVELOPED FOR  
RADIATION FIELD AND APPLIED TO LASER AMPLIFIERS  
A65-32707

MICROWAVE PROBLEMS IN ACOUSTIC WAVE INTERACTIONS,  
TRANSVERSE WAVE ELECTRON BEAM, OPTICAL  
SPECTROSCOPY OF LASER MATERIALS, AND NONLINEAR  
QUANTUM STUDIES  
ML-1243 N65-15605

QUANTUM AND CLASSICAL MECHANICAL THEORIES OF LASER  
RADIATION  
RM-4435-PR N65-19297

QUANTUM STATISTICAL PROCEDURE FOR STUDYING  
INTERACTING RADIATION FIELD APPLIED TO MODEL  
LASER OPERATING AS LINEAR AMPLIFIER  
RM-4516-PR N65-27655

COHERENT LIGHT RECORDING AND REPRODUCING SYSTEM  
COMPRISING TWO-DIMENSIONAL QUANTUM MECHANICAL  
DATA PROCESS OF ULTIMATE PACKING DENSITY AND  
FREQUENCY BANDWIDTH  
RADC-TR-65-130 N65-35528

QUANTUM RF PHYSICS TEXT COVERING MAGNETIC  
RESONANCE THEORY, ELECTRON PARAMAGNETIC RESONANCE,  
NUCLEAR MAGNETIC RESONANCES, TWO- AND THREE-LEVEL  
MASERS, RF GAS SPECTROSCOPY AND AMMONIA  
OSCILLATOR A66-10954

PHYSICAL FUNDAMENTALS OF LASERS SUCH AS POPULATION  
INVERSION, INDUCED EMISSION AND PRINCIPAL OPTICAL  
APPARATUS EXPLAINED FOR COMMUNICATIONS ENGINEERS  
A66-13233

QUANTUM MECHANICAL NONLINEAR THEORY OF INTENSITY  
AND PHASE FLUCTUATIONS OF HOMOGENEOUSLY BROADENED  
LASER NOISE A66-22466

QUANTUM OPTICS THEOREM ON CLASSICAL SOURCE FOR  
WHICH EFFECT OF DETECTOR AND DISSIPATION MECHANISM  
IS NEGLIGIBLE A66-22967

QUANTUM MECHANICAL TREATMENT OF MOLECULAR  
RADIATION BEHAVIOR IN DETUNING CAVITY OF DOUBLE  
CAVITY MASER  
FTD-TT-65-888/1&2&3&4 N66-19899

IMPROVED QUANTUM EFFICIENCY FROM LIGHT TRAPPED IN  
TRANSLUCENT PHOTOCATHODE LASER DETECTORS  
ITIL-66-1002 N66-20166

LASER THEORY WITH CLASSICAL AND QUANTUM MECHANICAL  
APPROACH TO ABSORPTION AND EMISSION  
R-1743 N66-20857

## QUANTUM THEORY

RELATION BETWEEN QUANTUM AND SEMICLASSICAL  
DESCRIPTION OF OPTICAL COHERENCE, CONSIDERING  
DISTRIBUTION FUNCTION A65-21379

RELATION BETWEEN OPTICAL COHERENCE AND PHOTON  
STATISTICS, USING CLASSICAL AND QUANTUM THEORY,  
INTERFERENCE EXPERIMENTS AND PHOTODETECTION  
A65-24002

QUANTUM THEORY OF OPTICAL PUMPING CYCLE DEVELOPED  
FROM ANALYSIS OF EFFECTS OF LIGHT ON ATOMIC ENERGY  
LEVELS A65-24003

QUANTUM THEORETICAL ANALYSIS OF LASER BEAM  
FLUCTUATIONS AND OF LIGHT BEAT EXPERIMENTS WITH  
TWO LASERS A65-25059

PERTURBED AND PLANE PARALLEL FABRY-PEROT  
RESONATORS, THERMAL FIELDS, QUANTUM OPTICAL  
COHERENCE, SPONTANEOUS EMISSION, AND DYNAMICAL  
THEORY OF LASER OSCILLATION  
AFCL-65-270 N65-27088

QUANTUM THEORY OF INTERACTION OF ELECTROMAGNETIC  
WAVES IN PLASMA CONSIDERED IN TERMS OF LIGHT-  
LIGHT SCATTERING AND PLASMA-LASER BEAM INTERACTION  
A66-21173

SECOND HARMONIC GENERATION BY LASER BEAMS OF  
FINITE SPECTRAL WIDTH, USING QUANTUM TRANSITIONS  
AND KINETIC EQUATIONS, NOTING SHAPE OF PUMPING  
LINE AT FUNDAMENTAL FREQUENCY A66-22026

## QUARTZ

SHORT-TERM FREQUENCY INSTABILITY AND FREQUENCY  
SPECTRA OF HIGHLY STABLE QUARTZ OSCILLATORS  
MEASURED, USING DOUBLE-BEAM AMMONIA MASER AS  
STANDARD A65-18320

LASER EXCITATION IN QUARTZ OF ELASTIC MODES OF  
THICK PLATE, SUGGESTING ENERGY COUPLING MECHANISMS  
A66-12423

## QUARTZ LIGHT

PERIODIC VARIATION OF QUALITY FACTOR OF HE-NE  
GAS LASER CAVITY BY VIBRATING QUARTZ-MODULATION OF  
LIGHT BEAM A66-13477

## QUENCHING

LASER DIGITAL DEVICES, EXAMINING QUENCHING OF GAIN  
AND OPTICAL ABSORPTION A66-14826

## R

## RABBIT

LASER IRRADIANCE LEVELS FOR RETINAL LESIONS  
A66-80011

CHORIORETINAL LESIONS PRODUCED BY LASER ON MONKEY  
AND RABBIT A66-80950

## RADAR

HIGH VOLTAGE, POWER, AND ENERGY FACILITIES FOR  
RADAR, LASERS, PLASMAS, AND COMMUNICATION  
COMPONENTS RESEARCH  
EB-5288-0536 N65-21673

## RADAR ANTENNA

OPTICAL ANALOG COMPUTER TRANSPOSING VARIABLE  
INPUTS INTO SPATIAL DIMENSIONS, USING LASER AS  
LIGHT SOURCE FOR ANTENNA MODELING AND SPECTRUM  
ANALYSIS A65-33770

## RADAR ASTRONOMY

TWO-CAVITY MASER AT 2388 MC FOR RADAR ASTRONOMY  
A65-29447

## RADAR BEAM

USE OF LASER BEAM IN SPECTROGRAPHIC ANALYSIS -  
NORMAL LASER AND GIANT SPIKE LASER  
AFCL-65-586 N66-12799

## RADAR DETECTOR

ATMOSPHERIC TURBULENCE, POWER FLUCTUATION AND  
RADAR DETECTION IN LASER SYSTEMS DESIGN  
A66-17294

## RADAR EQUIPMENT

LASER APPLICATION PROBLEMS IN INTERFEROMETRY,  
RADAR AND HOLOGRAPHY INCLUDING MECHANICAL  
STABILITY, NOISE SUPPRESSION, DIRTY LASER BEAM  
RESTORATION, ETC A66-11454

DEVELOPMENT IN U.S. OF LASER APPLICATION WITH  
TABLE INCLUDING GOVERNMENT SUPPORTED PROGRAMS IN  
PHOTOGRAPHY, DATA PROCESSING, RADAR, ETC  
A66-11455

## RADAR MEASUREMENT

LASER RANGEFINDER DEVICE PROVIDES FAST AND  
ACCURATE RANGE OF NONCOOPERATIVE TARGETS OPERATING  
ON RADAR PRINCIPLE A65-32586

# SUBJECT INDEX

# RADIATION FIELD

## RADAR SYSTEM

APPLICATION, PROBLEMS AND STATE OF LOW NOISE  
AMPLIFIERS AND TRAVELING WAVE TUBES, MASER AND  
ADLER TUBES GAIN IN RADAR SYSTEMS  
A66-14123

HIGH SENSITIVITY FAST-RESPONSE LASER DETECTION  
SYSTEM, DESCRIBING MICROWAVE RESPONSE  
PHOTOELECTRIC DETECTOR WITH AMPLIFICATION AND  
MIXING FUNCTIONS  
A66-22046

MEASUREMENT OF VERTICAL WATER VAPOR PROFILES BY  
MEANS OF THERMALLY TUNED RUBY LASER OPTICAL  
RADAR SYSTEM - HUMIDITY MEASUREMENT  
REPT.-65-6  
N66-14852

## RADAR TRANSMISSION

AIRBORNE LASER-RADAR LIGHT DETECTION AND RANGING  
/ LICAR/ SYSTEMS APPLIED TO DETECTION OF CLEAR AIR  
TURBULENCE / CAT/  
A66-15297

HIGH POWER LASER AMPLIFIER FOR OPTICAL RADAR  
TRANSMITTER - SPACE SURVEILLANCE SYSTEM  
EOS-5550-Q-1  
N66-12355

## RADIAL DISTRIBUTION

EXCITATION AND INVERSION METHOD IN GAS LASERS  
NOTING CHARACTERISTICS OF HELIUM-NEON LASER AND  
IONIZED AND THREE-LEVEL LASER SYSTEM  
A66-13951

## RADIATION

BIOLOGICAL EFFECTS OF LASER RADIATION AND SAFETY  
RULES FOR PERSONNEL PROTECTION  
NAVTRADEVCE-1H-15  
N65-14941

MOVING SURFACE VELOCITY MEASUREMENT USING LASER  
RADIATION  
GE/EE/64-18  
N65-17373

QUANTUM AND CLASSICAL MECHANICAL THEORIES OF LASER  
RADIATION  
RM-4435-PR  
N65-19297

RADIATION DIVERGENCE MEASUREMENT IN HELIUM-NEON  
LASERS WITH CONFOCAL RESONATORS AND SPHERICAL  
REFLECTORS  
N65-24550

STATISTICAL CHARACTERISTICS OF AUTOMODULATION OF  
SOLID LASER RADIATION  
N65-27234

EFFECT OF LASER RADIATION ON CHEMICAL ACTIVATION  
AND VAPOR FOG NUCLEATION  
MC-64-110-R1  
N65-27760

NONLINEAR ABSORPTION OF LASER RADIATION BY THREE-  
LEVEL ATOMIC SYSTEM  
RM-4478-PR  
N65-28654

THEORETICAL EXPLANATION FOR HIGHLY DIRECTIONAL  
OFF AXIAL RADIATION FROM SOLID STATE OPTICAL  
MASERS OF CIRCULAR CROSS SECTION  
TR-2  
N65-34713

RESONANT CAVITY, OSCILLATION AND RADIATION  
OUTPUT OF OPTICAL MASERS  
FTD-TT-64-1231/1626364  
N66-11458

## RADIATION ABSORPTION

LASER MODE OPERATION IN PRESENCE OF RADIATION  
ABSORBING IMPURITY ANALYZED BY EXTENDED THOMSON  
TYPE SYSTEM  
A65-35930

NONLINEAR ABSORPTION OF LASER RADIATION BY THREE-  
LEVEL ATOMIC SYSTEM  
RM-4478-PR  
N65-28654

ABSORPTION COEFFICIENT OF RUBY LASER RADIATION  
IN FULLY IONIZED LIGHT ELEMENTS  
IPP-6/27  
N65-30178

LASER RADIATION ABSORBED ALONG SLANT PATHS,  
SPECTRAL LINE OVERLAPPING AND CENTER LINE SHIFT  
WITH PRESSURE VARIATION  
A66-17295

## RADIATION DETECTOR

RUBY LASER OPTICAL RADAR DETECTION OF UPPER  
ATMOSPHERIC BACKSCATTERING  
A66-24395

## RADIATION DISTRIBUTION

GALLIUM ARSENIDE LASER DIODES BEHAVIOR AT HIGH  
PULSE RADIATION LOADS  
A65-29356

INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY  
AFTER LEAVING LASER AND AFTER FOCUSING WITHIN  
LENS, NOTING OPTIMUM FOCUSING CONDITIONS  
A65-36050

INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY  
AFTER LEAVING LASER AND AFTER FOCUSING WITHIN  
LENS, NOTING OPTIMUM FOCUSING CONDITIONS  
A66-15853

## RADIATION EFFECT

LASER RADIATION EFFECT ON VERTEBRATE EMBRYOS  
N65-16624

GAMMA RADIATION EFFECT ON ENERGY OUTPUT OF RUBY  
LASER CRYSTALS  
N65-17596

BIOLOGICAL EFFECTS OF LASER RADIATION WITH  
REFERENCE TO INTACT ANIMALS, PRIMATE EYES AND SKIN  
AND MALIGNANT TUMORS OF ANIMAL AND HUMAN ORIGIN  
A66-12994

PULSE ENERGY AND POWER OF LASERS UNDER CONTINUOUS  
OPERATING CONDITIONS MEASURED, USING CALORIMETERS,  
PHOTOELECTRIC EFFECT OF RADIATION, ETC  
A66-13205

PULSED IR LASER SIMULATING RADIATION-INDUCED  
TRANSIENT IONIZATIONS IN SEMICONDUCTOR DEVICES AND  
CIRCUITS  
A66-14853

RUBY LASER FOR STUDY OF LASER RADIATION EFFECTS  
ON BIOLOGICAL ORGANISMS  
CR-3885  
N66-10583

RUBY LASERS USED IN STUDYING PHYSICAL PROCESSES  
LEADING TO IONIZATION OF GASES BY INTENSE  
OPTICAL RADIATION  
UACRL-E920272-6  
N66-20600

OPTICAL ABSORPTION AND ELECTRON PARAMAGNETIC  
RESONANCE TECHNIQUES USED TO STUDY IGNIZING  
RADIATION EFFECT ON RUBY LASERS  
NASA-TN-D-3379  
N66-21037

## RADIATION EMISSION

RADIATION FLUCTUATIONS IN LASER PULSE REGIME,  
DISCUSSING ERRORS ARISING IN COMPARING BASIC WITH  
SECONDARY EMISSION  
A65-14617

OPTICAL MASER THEORY INCLUDING OSCILLATORS,  
RADIATION EMISSION, QUANTUM MECHANICS, ETC  
A65-24004

THEORY OF INDUCED AND SPONTANEOUS LASER EMISSION  
FROM ATOMIC LEVEL SYSTEM AND INCIDENT BEAMS OF  
RADIATION  
AFCRL-65-505  
N66-11992

## RADIATION FIELD

GEOMETRICAL PROPERTIES COMMON TO ALL MODES OF  
OSCILLATION IN RADIATION FIELD OF LASER  
INTERFEROMETERS  
A65-18795

MASER AND LASER PROPERTIES INCLUDING RADIATION  
FIELD AND MASER MEDIA, NOTING MOLECULAR  
AMPLIFICATION CENTERS AND ENGINEERING PROBLEMS  
A65-26935

OPTICAL SIMULATION OF MICROWAVE ANTENNAS WITHOUT  
DIRECT FREQUENCY SCALING, OBTAINING AMPLITUDE  
DISTRIBUTION OF LASER RADIATION FIELDS  
A65-25418

QUANTUM STATISTICAL PROCEDURE FOR STUDYING  
INTERACTING RADIATION FIELD APPLIED TO MODEL  
LASER OPERATING AS LINEAR AMPLIFIER  
RM-4516-PR  
N65-27655

LASER WITH DIFFRACTION LIMITED RADIATION PATTERN  
A66-10450

QUANTUM STATISTICS FOR ANALYZING RADIATION FIELDS  
INTERACTING WITH OTHER SYSTEMS APPLIED TO MODEL  
LASER OPERATING AS LINEAR AMPLIFIER

A66-13260  
LASER WITH DIFFRACTION LIMITED RADIATION PATTERN  
A66-13313  
SPATIAL AMPLITUDE OF FIELD OF IDEALLY PARALLEL  
LASER BEAM FOCUSED BY OPTICAL SYSTEMS WITH  
SPHERICAL ABERRATION A66-23778

**RADIATION HAZARD**  
PULSED LASER DOSIMETER THAT MEASURES DANGER LEVEL  
OF RADIATION OF DIRECT OR REFLECTED BEAMS AS  
SAFEGUARD TO EYE DAMAGE A65-21951  
BIBLIOGRAPHY ON BIOLOGICAL EFFECTS AND HAZARDS OF  
LASER RADIATION  
T5-1245/3111 N65-33997  
CHEMICAL PUMPING OF LASERS - EYE DAMAGE IN  
MONKEYS FROM LASER IRRADIATION  
U-3259 N66-13799  
STUDIES ON RADIATION PROTECTION FOR MAN, OPTICAL  
MASER OF NEODYMIUM IN TUNGSTATE, CYLINDER WAVE  
PROPAGATION ANALYSIS, AND ELECTROMOTIVE FORCE OF  
INDIUM ANTIMONIDE COMPOUND  
JPRS-33152 N66-15042

**RADIATION INTENSITY**  
RADIATIVE REACTION EFFECTS ON GIANT PULSE LASER  
STABILITY IN ANISOTROPIC MEDIUM A65-20913  
TIME DEPENDENCE OF LASER OPERATION MODES USING  
LASER MODEL WITH TWO OSCILLATION TYPES A65-27772  
CALCULATION OF RADIATION INTENSITY OBTAINED FROM  
LASER WITH HOMOGENEOUS LINE BROADENING GENERALIZED  
FOR ARBITRARILY LARGE LOSS FRACTION PER PASS  
A65-32219  
INTENSE LASER RADIATION PROPAGATION - LASER  
INDUCED GAS BREAKDOWN, PARAMETRIC INTERACTION,  
COHERENCE, ATMOSPHERIC ABSORPTION, OPTICAL  
SOURCE AND INSTRUMENTATION  
AFAL-TR-65-83 N65-25191  
INTERACTION OF INTENSE LASER BEAMS WITH MATERIALS  
AROD-4157-4 N65-27555  
CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION  
A66-11188  
TIME DEPENDENCE OF LASER OPERATION MODES, USING  
LASER MODEL WITH TWO OSCILLATION TYPES A66-16626  
SINGLE PULSE OPERATION OF LASERS, NOTING ENERGY  
STORAGE AND AMPLIFICATION EFFECT FOR FOUR- AND  
THREE-LEVEL ACTIVE MEDIUM A66-23667  
CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION  
A66-24009  
USE OF LASER BEAM IN SPECTROGRAPHIC ANALYSIS -  
NORMAL LASER AND GIANT SPIKE LASER  
AFCRL-65-586 N66-12799  
RUBY LASER RADIATION INTENSITY DISTRIBUTIONS BY  
HIGH SPEED CINEMATOGRAPHY AND TIME RESOLVED  
INTERFEROMETRY FOR PUMPED RADIATION EFFECTS  
N66-16657

**RADIATION MEASUREMENT**  
CD S SINGLE CRYSTAL OPTICAL GENERATOR DURING  
EXCITATION BY RUBY LASER, DISCUSSING TWO-PHOTON  
ABSORPTION COEFFICIENT AT 300 DEGREES K FOR  
RADIATION FLUX DENSITIES A66-13874  
MEASURING DEVICE FOR PULSED LASER OUTPUT POWER  
USING BOLOMETER, AMPLIFIER AND OSCILLOSCOPE  
A66-13888  
MEASUREMENT OF RADIATION PATTERN OF RUBY LASER  
EMISSION FOR VARIOUS RESONATORS AND OPERATING  
REGIMES, NOTING LASER EFFECT ON ANGULAR HALF-WIDTH  
VALUES A66-22028

**RADIATION MEDICINE**

LASER BEAM USE IN BIOLOGY AND MEDICINE, NOTING  
INTERACTION OF ELECTROMAGNETIC RADIATION WITH  
BIOLOGICAL SYSTEMS, HAZARDS, DIAGNOSTICS,  
THERAPEUTICS, ETC A66-14455

**RADIATION PROTECTION**

RADIATION PROTECTIVE DRUGS, XENON AND HELIUM-  
XENON LASERS, HELIUM-NEON LASER WITH SILVER AND  
DIELECTRIC COATINGS, AND TRANSISTOR CIRCUITS  
JPRS-29200 N65-20134

**RADIATION SPECTRUM**

INDUCED RADIATION IN GA AS SEMICONDUCTOR CRYSTAL  
EXCITED BY RUBY LASER WITH Q-MODULATION A65-35842

CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY  
SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY  
LASER A65-35866

CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY  
SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY  
LASER A66-19269

OPTICAL LASER PUMPS, HIGH POWER CW LASER  
OPERATION BY CATHODOLUMINESCENCE AND SUITABLE  
SELECTION OF PHOSPHORS A66-19546

THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-19669

THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-21836

RUBY LASER RADIATION SPECTRUM AND OPTICAL  
RESONANCE AT ROOM TEMPERATURE  
FTD-TT-65-1312/16264 N66-19914

**RADIATIVE RECOMBINATION**

RECOMBINATION RADIATION FROM GALLIUM ANTIMONIDE  
P-N JUNCTIONS, OBSERVING STIMULATED EMISSION AND  
LASER ACTION A65-30572

LASER TRANSITION IDENTIFICATION IN ELECTRON BEAM  
PUMPED GALLIUM ARSENIDE, PRIMARILY ON  
CONCENTRATION OF SHALLOW DONORS AND ACCEPTORS  
A66-10348

PROPAGATION OF ATMOSPHERICS, RADIATIVE  
RECOMBINATION IN LASERS, RADIATION BELT  
SURROUNDING EARTH, EQUATION FOR LAMINAR BOUNDARY  
LAYER PROBLEMS, AND RARE EARTH SILICIDES  
N66-12644

RADIATIVE RECOMBINATION WITH ELECTRON BEAM EXCITED  
CADMIUM TELLURIDE AND GALLIUM SELENIDE  
N66-12646

**RADIO ASTRONOMY**

OBSERVATIONS OF RADIO SOURCES AT 9.4 GC WITH 2.2  
FOOT FAN BEAM OF 16-ELEMENT INTERFEROMETER AND  
MASER AMPLIFIER A65-28335

DESIGN OF 8 MILLIMETER TRAVELING WAVE MASER  
FOR RADIO ASTRONOMY  
AD-619191 N65-35172

N EC MASER AMPLIFIER FOR RADIO ASTRONOMICAL  
OBSERVATION OF CYGNUS A, TAURUS A AND ORION  
AND OMEGA NEBULAS A66-15365

**RADIO ELECTRONICS**

PROCEEDINGS OF URSI GENERAL ASSEMBLY ON RADIO  
ELECTRONICS INCLUDING PLASMAS, MASERS AND LASERS  
AT TOKYO IN SEPTEMBER 1963 A65-26930

**RADIO EMISSION**

MULTICAVITY RADIOMETER MASERS FOR RECORDING 21 CM  
EMISSION FROM GALACTIC HYDROGEN  
N65-18885

**RADIO FREQUENCY**

TRANSITION PROCESSES OF OSCILLATION AMPLITUDE  
FORMATION IN RF THREE-LEVEL MASERS  
A65-15460

- TRANSITION PROCESSES OF OSCILLATION AMPLITUDE  
FORMATION IN RF THREE-LEVEL MASERS A65-28556
- RADIO FREQUENCY DISCHARGE**  
GAS MIXTURES AND PRESSURES FOR OPTIMUM OUTPUT  
POWER OF RF-EXCITED HELIUM-NEON GAS LASERS AT  
632.8 NM A65-22620
- RADIO FREQUENCY RADIATION**  
QUANTUM RF PHYSICS TEXT COVERING MAGNETIC  
RESONANCE THEORY, ELECTRON PARAMAGNETIC RESONANCE,  
NUCLEAR MAGNETIC RESONANCES, TWO- AND THREE-LEVEL  
MASERS, RF GAS SPECTROSCOPY AND AMMONIA  
OSCILLATOR A66-10954
- RADIO RECEIVER**  
MASER APPLICATIONS AS RADIO RECEIVERS, DISCUSSING  
MULTIRESONATOR ALL-PASS QUANTUM AMPLIFIERS A65-16282
- MASER APPLICATIONS AS RADIO RECEIVERS, DISCUSSING  
MULTIRESONATOR ALL-PASS QUANTUM AMPLIFIERS A65-25785
- RADIO SOURCE**  
TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
8-CM BAND A65-24882
- TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
8-CM BAND A65-36359
- RADIO TELESCOPE**  
TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
8-CM BAND A65-24882
- TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
8-CM BAND A65-36359
- FOREIGN SCIENCE BULLETIN - GIANT RADIO TELESCOPE  
RAMAN SCATTERING LASERS - FORECASTING SOLAR  
FLARES - MAN-IN-SPACE - EPITAXIAL GROWTH OF  
ALUMINUM NITRIDE THIN FILMS - TECHNOLOGY N65-30979
- GIANT RADIO TELESCOPE TO DETECT EXTRATERRESTRIAL  
RADIATION, RAMAN SCATTERING LASERS, FORECASTING  
SOLAR FLARES FOR MANNED SPACE FLIGHT, VOSKHOD  
II LIFE SUPPORT, AND ALUMINUM NITRIDE FILMS N65-32675
- RADIO TRANSMISSION**  
RADIO STATION FACILITIES AT RAISTING, WEST  
GERMANY NOTING SATELLITE COMMUNICATION, MASER  
RECEIVING SYSTEM, PARABOLIC ANTENNAS, ETC A65-35195
- RADIO TRANSMITTER**  
STATISTICAL MODEL OF RANDOM QUASI-SINUSOIDAL  
FUNCTION OF CONSTANT AMPLITUDE REPRESENTED BY  
EMISSION OF LASER OR RADIO TRANSMITTER A66-18637
- RADIOACTIVE ELEMENT**  
INVESTIGATIONS IN ASTRONOMY, SOLID STATE PHYSICS,  
OPTICAL MASERS, ATOMIC PHYSICS, AND RADIOACTIVE  
ATOMS FOR ELECTROMAGNETIC APPLICATIONS  
NASA-CR-70391 N66-17320
- RADIOLOGY**  
HAZARDS, EFFECT, SAFETY AND PRECAUTION FOR  
PREVENTION OF PHYSICAL INJURIES FROM LASER  
RADIATION A66-13694
- RADIOMETER**  
LOW NOISE KA-BAND TRAVELING WAVE MASER AMPLIFIER  
FOR WINDOW AT 8 MM WHERE ATMOSPHERIC ATTENUATION  
IS LOW A65-16565
- RADIOMETER MASERS, MICROWAVE GENERATION,  
BIOLOGICAL ASPECTS OF MICROWAVES, POLYMERIZATION  
AND OPTIMAL CONTROL AD-455792 N65-18884
- MULTICAVITY RADIOMETER MASERS FOR RECORDING 21 CM
- EMISSION FROM GALACTIC HYDROGEN N65-18885
- RADIOMETRY**  
RADIOMETRIC PERFORMANCE OF SOLID STATE  
SUPERHETERODYNE RECEIVER COMPARABLE TO THAT  
OBTAINED WITH MASERS AND PARAMETRIC AMPLIFIERS  
A66-12437
- RECORDING SAMPLING SYSTEM FOR MEASURING ENERGY  
INCIDENT ON BIOLOGICAL SYSTEM EXPOSED TO LASER  
BEAM A66-17293
- RAMAN EFFECT**  
NONLINEAR OPTICAL EFFECTS IN CRYSTALLINE AND  
ISOTROPIC MATERIALS DUE TO INDUCED POLARIZATION  
THIRD ORDER IN ELECTRIC FIELD STRENGTH, USING  
GIANT PULSED LASER SOURCE A65-16863
- STIMULATED RAMAN EFFECT OF BENZENE USING RUBY  
LASER, EXAMINING OUTPUT SPECTRUM, THRESHOLD POWER  
AND EFFICIENCY AT STOKES LINES A65-19598
- OPTICAL PARAMETRIC AMPLIFICATION INVOLVING THREE  
WAVES, OPERATION OF HIGH POWER, NEARLY SINGLE  
PULSED RUBY LASER, AND OBSERVATION OF PARAMETRIC  
INTERACTION AMONG RAMAN-SHIFTED LINES  
RADC-TDR-64-386 N65-14311
- LASERS AND LASER SPECTROSCOPY - LIGHT MODULATION  
AND DEMODULATION METHODS, LASER TRANSITIONS,  
RAMAN EFFECT INITIATION, AND NONLINEAR OPTICAL  
PHENOMENA TR-A-34 N65-19791
- SPECTRAL AND TRANSIENT CHARACTERISTICS OF SOLID  
STATE AND SEMICONDUCTOR LASERS, AND NONLINEAR  
INTERACTION OF COHERENT LIGHTWAVES DUE TO RAMAN  
EFFECT S-702 N65-21558
- OPTICALLY PUMPED SEMICONDUCTOR LASER IN U.S.S.R.  
N65-30208
- GAIN MEASUREMENTS OF RAMAN AMPLIFIER PUMPED BY  
DIFFUSE RUBY RADIATION A66-16388
- COHERENCE AND STIMULATION THRESHOLD OF STOKES  
LINE A66-18648
- EQUATIONS OBTAINED FROM HAMILTONIAN FOR COUPLING,  
FIRST STOKES LINE, FIRST ANTI-STOKES LINE AND  
COHERENT FIELD FOR RAMAN LASER A66-22490
- RAMAN SCATTERING**  
STIMULATED BRILLOUIN RADIATION IN OFF-AXIS RUBY  
LASER RESONATOR USING CARBON DISULFIDE CELL,  
EXAMINING OUTPUT SPECTRUM A65-16811
- GIANT PULSE LASER APPLIED TO NONLINEAR OPTICAL  
EFFECT OF STIMULATED RAMAN SCATTERING WITH  
REFERENCE TO EMISSION ANGLE MEASUREMENT TECHNIQUE  
A65-19996
- LASER APPLICATION IN CHEMICAL COMPOSITION ANALYSIS  
OF MATERIAL BY SPECTROSCOPIC TECHNIQUE,  
CONSIDERING ORGANIC SUBSTANCE AND PLASMA A65-20004
- FIRST ORDER RAMAN SCATTERING MEASUREMENT IN  
SILICON USING 6328-ANGSTROM OUTPUT OF HELIUM-NEON  
LASER A65-26457
- LASER BEAM MULTIMODE EFFECTS AS HINDRANCE TO  
INTERPRETATION OF QUANTITATIVE MEASUREMENTS OF  
RAMAN GAIN A65-26958
- RAMAN DIFFUSION OF LIQUIDS PLACED OUTSIDE OPTICAL  
CAVITY AND EXCITED BY RUBY LASER A65-27944
- OBSERVED AND PREDICTED EFFICIENCY OF CONVERSION OF  
RADIATION FROM GIANT PULSE RUBY LASER INTO  
STIMULATED RAMAN SCATTERING A65-32209
- COHERENTLY DRIVEN MOLECULAR VIBRATIONS AND LIGHT  
MODULATION - RAMAN SCATTERING BY MASER BEAM

- NASA-CR-58211 N65-14531
- NONLINEAR OPTICS - LASERS, RAMAN SCATTERING,  
AND OPTICAL RESONATORS N65-21141  
JPRS-29459
- FOREIGN SCIENCE BULLETIN - GIANT RADIO TELESCOPE  
RAMAN SCATTERING LASERS - FORECASTING SOLAR  
FLARES - MAN-IN-SPACE - EPITAXIAL GROWTH OF  
ALUMINUM NITRIDE THIN FILMS - TECHNOLOGY N65-30979
- GIANT RADIO TELESCOPE TO DETECT EXTRATERRESTRIAL  
RADIATION, RAMAN SCATTERING LASERS, FORECASTING  
SOLAR FLARES FOR MANNED SPACE FLIGHT, VOSKHOD  
II LIFE SUPPORT, AND ALUMINUM NITRIDE FILMS N65-32675
- RAMAN SCATTERING LASERS N65-32677
- CURRENT STATUS OF THEORETICAL AND EXPERIMENTAL  
STUDIES OF VARIANT OF RAMAN EFFECT ENCOUNTERED IN  
SCATTERING OF LASER LIGHT A66-12065
- STIMULATED BRILLOUIN AND RAMAN SCATTERING IN  
GASES, DISCUSSING SOUND VELOCITY CALCULATION FROM  
FREQUENCY SHIFT AND ARGON, HYDROGEN AND NITROGEN A66-13981
- STIMULATED RAMAN AND BRILLOUIN SCATTERING FOR  
STOKES RADIATION PARALLEL TO LASER BEAM IN  
RECTANGULAR WAVEGUIDE A66-14901
- RAMAN LASER MATERIALS SELECTION, EMPHASIZING  
FREQUENCY SHIFTS AND EXCITATION POWER THRESHOLD A66-23477
- LASER APPLICATION AND TECHNIQUES NOTING  
AMPLIFICATION, MODULATION, INTERFEROMETRY,  
SCATTERING, PLASMA DIAGNOSTICS, NONLINEAR OPTICS,  
ETC A66-23931
- OPTICAL MASER AS POWER SOURCE FOR NARROW BAND  
ELECTROMAGNETIC RADIATION THROUGH STIMULATED  
RAMAN SCATTERING - SOLID STATE PHYSICS  
REPT.-1935-6 N66-10581
- LASER-INDUCED NONLINEAR EFFECTS, RAMAN  
SCATTERING, AND GAS BREAKDOWN - SCVIET  
LITERATURE REVIEW N66-12270  
ATD-P-65-74
- PHONON-PHOTON INTERACTIONS IN OPTICAL SOURCES -  
THEORETICAL DESCRIPTION OF BRAGG AND  
RAMAN-NATH SCATTERING CAUSED BY PROPAGATION OF  
PLANE ACOUSTIC WAVE THROUGH LASER BEAM PATH N66-22449  
AFOSR-65-2647
- MICROWAVE RADIATION RESEARCH - ACOUSTIC WAVE  
AMPLIFICATION, OPTICAL MASERS, SEMICONDUCTOR  
OSCILLATIONS, RAMAN SCATTERING, FERROMAGNETIC  
BULK INSTABILITIES, AND NONUNIFORM PLASMAS N66-22741  
ML-1410
- RAMAN SPECTROSCOPY**
- HELIUM-NEON GAS LASER USED IN RAMAN SPECTROSCOPY A66-19232
- ANGULAR DEPENDENCE OBSERVATIONS, ABSORPTION  
MEASUREMENTS, AND HIGH INTENSITY GAS LASER  
CONSTRUCTION IN STIMULATED RAMAN EMISSION AND  
ABSORPTION SPECTROSCOPY STUDY N66-23584  
AD-626747
- RAMAN SPECTRUM**
- OPTICAL MIXING OF NITROBENZENE RAMAN RUBY LASER  
LIGHT IN ADP AND OTHER NONLINEAR DIELECTRIC MEDIA A65-15951
- MODULATION INDUCING RETRODIRECTING OPTICAL  
SYSTEM - DIODE MOUNT FOR GALLIUM ARSENIDE  
LASERS, AND GENERATION OF ALKALINE LINE BY  
STIMULATED RAMAN EMISSION N65-21342  
NASA-CR-57922
- POWER AND PATH LENGTH EFFECTS ON STIMULATED RAMAN  
SPECTRA IN METHANE AND HYDROGEN STUDIES USING  
GIANT PULSED LASER N66-20037
- RANDOM NOISE**
- STATISTICS OF MULTIMODE LASER SIGNALS DERIVED AND  
COMPARED WITH THOSE OF INCOHERENT RADIATION A65-31034
- INTENSITY FLUCTUATIONS MEASURED IN EMISSION FROM  
VARIOUS LASING AND NONLASING MODES OF CONTINUOUS  
WAVE GAS LASER A65-34687
- RANDOM SIGNAL**
- STATISTICAL MODEL OF RANDOM QUASI-SINUSOIDAL  
FUNCTION OF CONSTANT AMPLITUDE REPRESENTED BY  
EMISSION OF LASER OR RADIO TRANSMITTER A66-18637
- RANDOM VARIABLE**
- CORRELATION FUNCTIONS OF AMPLITUDE AND INTENSITY  
FLUCTUATION FOR LASER MODEL NEAR THRESHOLD  
OBTAINED BY USING DISTRIBUTION FUNCTIONS EVALUATED  
BY FOKKER-PLANCK EQUATION, TREATING AMPLITUDE AS  
RANDOM VARIABLE A66-25018
- RANGE AND RANGE RATE TRACKING**
- LASER USE IN LONG RANGE MEASUREMENT OF  
TRAJECTORIES CNRA TP 166 A65-19046
- RANGE INDICATOR**
- DIGITAL TIME-INTERVAL COUNTER /RANGEMETER/ FOR USE  
WITH LASER RANGEFINDER N65-14460  
HDL-TR-1262
- RANGE MEASUREMENT**
- LASER RANGEFINDER DEVICE PROVIDES FAST AND  
ACCURATE RANGE OF NONCOOPERATIVE TARGETS OPERATING  
ON RADAR PRINCIPLE A65-32586
- OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER  
AS AIRCRAFT ALTITUDE TO ELIMINATE SPURIOUS ECHOS A65-32588
- GAS LASER RANGE MEASUREMENT DEVICE GIVING HIGH  
ACCURACY DIFFERENTIAL TERRAIN HEIGHT INFORMATION N65-33571  
FROM AIRBORNE PLATFORM
- RANGEFINDING**
- LASER RANGEFINDERS N65-16822  
NDS-TP-3539
- LASER RANGEFINDER DESIGN - LASER RADAR COMPARISON,  
WAVELENGTH DEPENDENCE AND CONSIDERATIONS FOR  
DETECTION, COMPONENTS, BACKGROUND AND DETECTOR  
NOISE, OUTPUT ATTENUATION, AND RIFLE RANGEFINDER  
NAWEP-8674 N65-22879
- RARE EARTH**
- CRYSTAL GROWTH AND PREPARATION OF POTENTIAL LASER  
MATERIAL CONTAINING RARE EARTH IONS AS DOPANTS A65-17042
- RARE EARTHS IN OPTICAL MASER MATERIALS, DISCUSSING  
CHEMICAL INTERACTIONS BETWEEN ACTIVE ION AND HOST  
LATTICE A65-17052
- LASER ACTION IN RARE EARTH CHELATES, EMPHASIZING  
CHEMISTRY AND SPECTROSCOPIC PROPERTIES OF  
MATERIALS AND PROPERTIES OF LIQUID LASER A65-20074
- OPTICAL PUMPING ENERGY TRANSFER MECHANISM IN RARE  
EARTH CHELATES NOTING POSSIBILITY AS LASER  
MATERIAL A65-20075
- PULSED AND CONTINUOUS WAVE LASER OPERATION OF  
THULIUM ION DOPED ERBIUM OXIDE WHICH PROVIDES  
PUMPING MECHANISM BY MEANS OF ENERGY TRANSFER A65-26955
- HIGH QUANTUM EFFICIENCY IN NARROW BAND TRIVALENT  
RARE EARTH DOPED QUANTUM COUNTER ACHIEVED BY LASER  
PUMPING A65-27604
- ENERGY TRANSFER IN RARE EARTH CHELATES -  
IMPLICATIONS FOR ORGANIC LASER DESIGN N65-15505
- RARE EARTH CHELATE LASERS N65-15508
- LASER CHARACTERISTICS OF AND COHERENT OSCILLATIONS

# SUBJECT INDEX

# REFRACTIVE INDEX

- FROM TRIVALENT TM, HO, YB AND ER IONS IN  
YTTRIUM ALUMINUM GARNET A66-10241
- PREPARATION OF SINGLE CRYSTALS OF DOUBLE  
MOLYBDATE OF NA AND LA FOR OTHER RARE EARTH  
ELEMENTS/ DOPED WITH ND, TB OR PR FOR LASER  
APPLICATION A66-13478
- PROPAGATION OF ATMOSPHERICS, RADIATIVE  
RECOMBINATION IN LASERS, RADIATION BELT  
SURROUNDING EARTH, EQUATION FOR LAMINAR BOUNDARY  
LAYER PROBLEMS, AND RARE EARTH SILICIDES N66-12644
- RARE EARTH COMPOUND**  
THEORETICAL OPTICAL RESONATOR FOR LASER WITH RARE  
EARTH LIQUID SOLUTIONS AS ACTIVE COMPONENTS A66-21970
- LUMINESCENCE IN RARE EARTH DOPED II-VI COMPOUNDS  
AND SPECTRAL EMISSION CHARACTERISTICS OF LASER  
OSCILLATORS ML-1346 N66-16740
- PHOTOLUMINESCENCE LINE STRUCTURE OF ZINC SULFIDE  
AND CADMIUM SULFIDE CRYSTALS DOPED WITH RARE  
EARTHS - LASER MATERIALS N66-16741
- COORDINATION AND CHEMICAL EQUILIBRIUM IN CHELATE  
LASER MATERIALS N66-20730
- RARE GAS**  
NOBLE GAS MOLECULAR SCATTERING OF RUBY LASER LIGHT  
COMPARED WITH RAYLEIGH THEORY A65-15438
- HELIUM-NEON LASER RADIATION DISPERSION MEASUREMENT  
IN TRANSITION 3S2-2P4 FOR VARYING MIRROR SPACING  
A65-19693
- HE- NE LASER PROPERTIES AND LASER MECHANISM OF NE  
ATOMS, NOTING TRANSITION PROCESS AND OSCILLATION  
DYNAMICS A65-19999
- NOBLE GAS-OXYGEN LASER OPERATION UNDER O13 TRIPLE  
P EXCITATION THROUGH COLLISION-INDUCED OXYGEN  
DISSOCIATION, NOTING BANDWIDTHS AND OSCILLATIONS  
A65-21810
- LASER OSCILLATION IN PULSED NOBLE-GAS-ION LASER AT  
NEAR- IR A65-22785
- NOBLE GAS-OXYGEN LASER OPERATION UNDER O13  
TRIPLE P EXCITATION THROUGH COLLISION-INDUCED  
OXYGEN DISSOCIATION, NOTING BANDWIDTHS AND  
OSCILLATIONS A65-24862
- U V ION LASER TRANSITIONS IN INERT GASES, OXYGEN  
AND NITROGEN BETWEEN 2300 AND 4000 ANGSTROMS,  
SHOWING RELATIONSHIP BETWEEN GAIN AND TUBE  
DIAMETER A65-27334
- PHOTOBEAT CHARACTERISTICS BETWEEN TWO  
INDEPENDENTLY STABILIZED HE- NE LASERS A65-29117
- HELIUM-NEON LASER OUTPUT CHARACTERISTICS AS  
FUNCTION OF LASER PARAMETERS A65-31375
- MODULATION OF HELIUM-NEON LASER BY LIGHT FROM  
HELIUM DISCHARGE A65-33006
- LASER EXCITATION IN FREON AND RARE GAS MIXTURES  
BASED ON DISSOCIATIVE EXCITATION PROCESS AND  
QUENCHING ACTION OF SOME GASES A65-35043
- ELECTRON BEAM PUMPING OF NOBLE GAS ION LASER  
A66-10350
- ALUMINUM COLD CATHODES WITH SINGLE MODE  
6328 ANGSTROM HELIUM-NEON GAS LASER LIFETIMES  
EXCEEDING 3000 HOURS A66-10855
- HELIUM-NEON LASER OUTPUT CHARACTERISTICS AS  
FUNCTION OF LASER PARAMETERS A66-14897
- BEAT FREQUENCY AND ROTATION OF POLARIZATION PLANE  
IN HE- NE LASER WITH AXIAL MAGNETIC FIELD  
A66-18430
- ISOLATION OF 1.0621 LINE IN HE- NE GAS LASER BY  
MULTILAYER DIELECTRIC-COATED MIRRORS WITH SHARP  
SPECTRAL CUT-OFF CHARACTERISTICS A66-20517
- C W LASER ACTION ON TRIPLE STATE PHOSPHORUS-SULFUR  
TRANSITION, USING HYDROGEN SULFIDE-NOBLE GAS  
MIXTURES A66-21577
- RAYLEIGH SCATTERING**  
OPTICAL RADAR OBSERVATION OF UPPER ATMOSPHERIC  
CONSTITUENTS BY LASER BEAMS, EXAMINING NEW METHODS  
BY RESONANCE SCATTERING OF VARIOUS WAVELENGTHS  
A65-14683
- NOBLE GAS MOLECULAR SCATTERING OF RUBY LASER LIGHT  
COMPARED WITH RAYLEIGH THEORY A65-15438
- RAYLEIGH SCATTERING USING LASER LIGHT FOR  
DETERMINATION OF SCATTERING DENSITY OF ARGON,  
OXYGEN, AND NITROGEN R-135 N65-26127
- REAL TIME**  
REAL TIME, PROJECTION DISPLAY SYSTEM USING LASER  
LIGHT SOURCE UI-903600-1 N65-35989
- RECTANGULAR GUIDE**  
STIMULATED RAMAN AND BRILLOUIN SCATTERING FOR  
STOKES RADIATION PARALLEL TO LASER BEAM IN  
RECTANGULAR WAVEGUIDE A66-14901
- RECTIFICATION**  
OPTICAL RECTIFICATION IN CRYSTALS USING RUBY  
LASER BEAM TID-21807 N65-35445
- REFLECTED WAVE**  
REFLECTION GRATINGS AS END PLATES IN FABRY-  
PEROT CAVITY, WITH CHARACTERISTICS OF LOW  
ABSORPTION OUTPUT COUPLING AND WAVELENGTH-  
DEPENDENT ALIGNMENT OF END PLATES A66-19930
- REFLECTING TELESCOPE**  
VIGNETTING TEST FOR MIRROR TELESCOPE USING CW  
LASER A65-25826
- REFLECTION COEFFICIENT**  
REFLECTION COEFFICIENT OF MIRRORS MEASURED ON  
OPERATING WAVELENGTH OF LASER IN WHICH THEY ARE  
USED A65-25589
- REFLECTION COEFFICIENT OF CAVITY TUBING AS  
EXPLANATION FOR POWER LEVEL OF HELIUM-NEON IR  
FABRY- PEROT INTERFEROMETER A65-30342
- REFLECTION COEFFICIENT OF MIRRORS MEASURED ON  
OPERATING WAVELENGTH OF LASER IN WHICH THEY ARE  
USED A66-11420
- REFLECTOMETER**  
LASER SOURCE REFLECTOMETER TO MEASURE REFLECTANCE  
OF SPECIMENS AT HIGH TEMPERATURE - RELATION OF  
THERMAL EMISSION TO OTHER OPTICAL PROPERTIES  
NBS-TM-267 N66-22418
- REFLECTOR**  
SATELLITE REFLECTOR DESIGN FOR LASER BEAM  
RETROREFLECTION AND SATELLITE SIGNAL  
TRANSMISSION CALCULATIONS NASA-TM-X-55129 N65-18254
- RADIATION DIVERGENCE MEASUREMENT IN HELIUM-NEON  
LASERS WITH CONFOCAL RESONATORS AND SPHERICAL  
REFLECTORS N65-24550
- GAS LASER END REFLECTOR USING PELLIN- BROCA PRISM  
FOR SPECTRAL LINE SELECTION A66-20518
- REFRACTIVE INDEX**  
CHROMIUM INDUCED LIGHT DISPERSION IN R LINES OF  
RUBY, NOTING REFRACTION SHIFT IN LASER SPECTRUM  
A65-20260
- IMMERSION LIQUIDS FOR HIGH ENERGY RUBY LASERS WITH  
MATCHING REFRACTIVE INDEXES TRANSPARENT AT RUBY  
PUMPING AND LASING WAVELENGTHS A65-22625



- REFRACTIVE INDEX OF SOLID DETERMINED, USING FAR IR MICHELSON INTERFEROMETER ILLUMINATED WITH RADIATION FROM CN MASER A65-24683
- USE OF REFRACTIVE INDEX VARIATION CAUSED BY PROPAGATION OF ULTRASONIC WAVES IN LASER FEEDBACK INTERFEROMETER TO CONTROL LASER OUTPUT C-920083-12 N65-15207
- REFRACTIVE INDEX VARIATION DURING LASER OPERATION AND CAST-PLASTIC OPTICAL-PUMP CAVITY EQUIPMENT FOR PUMPING AND TEMPERATURE CONTROL DURING EXPERIMENT SATR-1 N65-15753
- EFFECT OF COMPOSITION ON THERMAL EXPANSION COEFFICIENT, THERMAL COEFFICIENT OF REFRACTIVE INDEX, BIREFRINGENCE, AND STRESS-OPTICAL COEFFICIENTS FOR ATHERMALIZING LASER GLASS TSR-5 N65-25688
- EFFECT OF OPTICAL PUMPING ON ANOMALOUS DISPERSION IN SELECTED RUBY LASERS AND VARIATION OF REFRACTIVE INDEX DURING LASER OPERATION SATR-3 N65-28619
- LASER INDUCED GAS BREAKDOWN AT HIGH PRESSURES, NOTING EFFECT OF PLASMA DENSITY ON INDEX OF REFRACTION VIA OPTICAL FREQUENCY RESONANCE MEASUREMENT A66-21564
- LASER PHYSICS CONFERENCE - ENERGY EXCHANGE IN SOLIDS AND GASES, NONLINEAR EFFECTS, GAS BREAKDOWN, AND REFRACTIVE INDEX VARIATION AD-622507 N66-14573
- DYNAMICS AND CHARACTERISTICS OF SELF-TRAPPING OF INTENSE LIGHT BEAMS NASA-CR-74030 N66-23765
- REFRIGERATING EQUIPMENT**  
TRAVELING WAVE MASER SUPERCONDUCTING MAGNET COOLED IN CLOSED-CYCLE REFRIGERATOR BY THERMAL CONDUCTION A65-32128
- REGENERATION**  
REGENERATIVE RUBY LASER AMPLIFIERS AT LIQUID NITROGEN TEMPERATURES ECOM-2575 N65-35642
- REGENERATIVE CYCLE**  
THRESHOLD CONDITIONS FOR CONTINUOUS SELF-SUSTAINED OSCILLATIONS PRODUCED BY REGENERATIVE RUBIDIUM GAS MASER A65-17659
- MULTIPLE REFLECTION THEORY APPLIED TO REGENERATIVE LASER AMPLIFIER DESIGN ECOM-2531 N65-19166
- RELATIVISTIC VELOCITY**  
OPTICAL DIFFRACTION VELOCIMETER, USING BACKSCATTERED LASER LIGHT TO MEASURE RELATIVE VELOCITY BETWEEN LIGHT SOURCE AND SURFACE A66-22958
- RELATIVITY THEORY**  
COHERENT LASER BEAM USED TO SHOW CONSTANCY OF VELOCITY OF ELECTROMAGNETIC RADIATION A65-14215
- LECTURE MANUSCRIPTS ON HIGH ALTITUDE EXPLOSIONS, BIOLOGICAL EXPLORATION OF MARS, MASERS AND LASERS, PLANETARY ATMOSPHERES, RELATIVITY THEORY, ELEMENT ABUNDANCE, AND SOLAR PARTICLES N65-31360
- FIRST-ORDER RELATIVITY TEST USING PHASE CHANGE OF TWO COHERENT BEAMS A66-19935
- CARNAHAN PROPOSED FIRST ORDER ETHER DRIFT EXPERIMENT USING TWO LASERS SHOWN TO BE OF SECOND ORDER NATURE, NOTING ROLE OF PHASE SHIFTS A66-21656
- RELAXATION**  
RELAXATION OSCILLATIONS IN EMISSION OF RUBY LASERS UNDER VARIOUS OPERATIONAL CONDITIONS T-G-215 N65-24968
- RUBY LASER TEMPERATURE-JUMP RELAXATION KINETIC STUDIES OF RAPID REACTIONS UUCD-2-64 N66-23078
- RELAXATION TIME**  
MEASUREMENT OF GAS LASER RADIATIVE DECAY RATES AND TOTAL INELASTIC DESTRUCTIVE CROSS SECTION OF SHORT LIVED EXCITED STATES IN 4-NSEC TO 1000-NSEC RANGE A65-20061
- CHROMIUM ALIGNMENT IN RUBY BY OPTICALLY PUMPING RUBY SAMPLE WITH CIRCULAR POLARIZED RADIATION FROM RUBY LASER A65-33418
- SOLID STATE LASER OUTPUT EXHIBITING REGULAR AND IRREGULAR SPIKES ANALYZED THROUGH RELAXATION OSCILLATIONS AND CLASSICAL PHYSICS A66-20568
- SPATIALLY INDEPENDENT LASER RATE EQUATION GENERALIZED FOR MULTIMODE EFFECTS, NOTING STEADY STATE OSCILLATION THRESHOLD SINGULARITIES, SPIKING PARAMETERS, ETC A66-24560
- PULSED INDUCED EMISSION IN HYDROGEN BEAM LASER FOR CASE OF TWO RELAXATION TIMES, DETERMINING POLARIZATION ONLY BY NUMBER OF ACTIVE PARTICLES IN RESONATOR A66-24884
- RENDEZVOUS GUIDANCE SYSTEM**  
OPTICAL RENDEZVOUS GUIDANCE SYSTEM AND GROUND BASED OPTICAL TRACKING SYSTEM DEVELOPMENT N66-23458
- RESONANCE**  
SOLID STATE DEVICE, LASER, MATERIALS, BAND STRUCTURE AND SPECTROSCOPY OF SOLIDS, AND MAGNETISM AND RESONANCE RESEARCH ESD-TDR-64-560 N65-16944
- SOLID STATE PHYSICS - LASERS, SPECTROSCOPY OF SOLIDS, MAGNETISM, AND RESONANCE ESD-TDR-64-561 N65-19317
- LASER, MATERIALS, AND SOLID STATE RESEARCH, BAND STRUCTURE AND SOLIDS SPECTROGRAPHY, AND MAGNETISM AND RESONANCE ESD-TDR-64-349 N65-19816
- SOLID STATE RESEARCH REPORT INCLUDING SOLID STATE DEVICES, LASERS, MATERIALS, BAND STRUCTURE, MAGNETISM AND RESONANCE, AND SPECTROSCOPY OF SOLIDS ESD-TDR-65-31 N65-25537
- RESONANCE EFFECT**  
INDUCED RADIATION AT HIGH PHOTON DENSITIES, NOTING APPLICABILITY OF PERTURBATION THEORY TO MULTIPHOTON RESONANCE RADIATION OF LASERS A66-20344
- RESONANCE SCATTERING**  
OPTICAL RADAR OBSERVATION OF UPPER ATMOSPHERIC CONSTITUENTS BY LASER BEAMS, EXAMINING NEW METHODS BY RESONANCE SCATTERING OF VARIOUS WAVELENGTHS A65-14683
- RESONANT CAVITY**  
LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS A65-36356
- MODE DEGENERACY-DIPS ON OUTPUT OF HE-NE LASER FOR CERTAIN CRITICAL COMBINATION OF MIRROR CURVATURES AND SEPARATION A65-36703
- THEORETICAL STUDY OF RESONANT MODES OF LASER CAVITY WITH END MIRRORS AND PERIODIC REFLECTIVITY AFCL-64-1015 N65-17931
- UNSTABLE OPTICAL RESONATORS FOR RUBY LASER APPLICATIONS ML-1227 N65-33916
- EFFECT OF LOAD MISMATCH ON LASER OUTPUT, DETERMINING NONLINEAR DEPENDENCE OF EQUIVALENT NEGATIVE CONDUCTANCE AS FUNCTION OF OSCILLATION

# SUBJECT INDEX

## RUBY LASER

- AMPLITUDE IN LASER RESONATOR CAVITY  
A66-20435
- INFLUENCE OF RESONANT CAVITY, XENON LIGHT, AND  
OTHER PARAMETERS ON RUBY LASER EMISSION ENERGY  
OUTPUT  
FTD-TT-64-1339/1&2&3&4 N66-11522
- RESONANT FREQUENCY  
RESONANT WAVES IN FABRY-PEROT INTERFEROMETER  
INVESTIGATED ON BASIS OF STANDING WAVE TYPE  
FORMULATION A65-33516
- MODULATION OF LASER LIGHT WITH COMPOSITE FABRY-  
PEROT RESONATOR, USING MORE THAN THREE MULTIPLE  
REFLECTING PLATES A66-15836
- TWO-FREQUENCY VOLUME RESONATOR WITH INDEPENDENT  
TUNING WITHIN WIDE FREQUENCY BAND A66-18918
- LASER CONFIGURATION GENERATING SINGLE FREQUENCY  
RADIATION IN SINGLE SPATIAL MODE WITH HIGH OUTPUT  
ACHIEVED BY SUPPRESSING ALL RESONANCES BUT ONE  
A66-21250
- RESONANT VIBRATION  
MINIMUM VALUE OF TIME DEPENDENT LASER RADIATION  
LOSSES AT WHICH GIANT OSCILLATIONS OCCUR  
A65-19740
- LASER ACTION ON P- AND R-BRANCH TRANSITIONS OF  
CARBON DIOXIDE VIBRATIONAL SPECTRUM BAND PRODUCED  
BY PULSED DISCHARGE ADMIXTURE OF VARIOUS GASES  
A65-33058
- RESONATOR  
MASER WITH TWO SERIES RESONATORS N65-13904
- RADIATION DIVERGENCE MEASUREMENT IN HELIUM-NEON  
LASERS WITH CONFOCAL RESONATORS AND SPHERICAL  
REFLECTORS N65-24550
- PERTURBED AND PLANE PARALLEL FABRY-PEROT  
RESONATORS, THERMAL FIELDS, QUANTUM OPTICAL  
COHERENCE, SPONTANEOUS EMISSION, AND DYNAMICAL  
THEORY OF LASER OSCILLATION  
AFCL-65-270 N65-27088
- OPTICAL RADAR TECHNIQUES - STUDIES OF NEAR  
HEMISPHERICAL RESONATOR GAS LASER  
REPT.-1641-6 N66-12795
- AMMONIA MASER - AMMONIA MOLECULAR GENERATOR  
FTD-TT-65-803/1&2&4 N66-19855
- RETINA  
LASER IRRADIANCE LEVELS FOR RETINAL LESIONS  
A66-80011
- RETINAL VASCULATURE OF RABBIT AND MONKEY AS  
AFFECTED BY LASER IRRADIATION PROXIMITY OF  
PIGMENT EPITHELIUM, BLOOD FLOW, AND AMOUNT OF  
REDUCED HEMOGLOBIN A66-80470
- CHORIORETINAL LESIONS PRODUCED BY LASER ON MONKEY  
AND RABBIT A66-80950
- RLC CIRCUIT  
AMPLITUDE NOISE ANALYSIS OF MASER OSCILLATOR,  
USING VAN DER POL EQUIVALENT CIRCUIT  
A65-33375
- ROCKET MEASUREMENT  
ROCKET MISSILE ATTITUDE SENSING DURING EARLY  
LAUNCH PHASE USING POLARIZED LASER BEAMS  
TRANSMITTED FROM GROUND STATION  
A65-23619
- ROOM TEMPERATURE  
METHODS OF JUNCTION FORMATION TO OBTAIN ROOM  
TEMPERATURE GALLIUM ARSENIDE LASER DIODES  
QPR-3 N65-34184
- RUBY LASER RADIATION SPECTRUM AND OPTICAL  
RESONANCE AT ROOM TEMPERATURE  
FTD-TT-65-1312/1&2&4 N66-19914
- ROOM TEMPERATURE OPERATION OF PULSED GALLIUM  
ARSENIDE INJECTION LASER, AND IMPROVEMENT OF  
LASER DIODE STRUCTURE  
ECOM-01501-1 N66-20809
- ROTATING MIRROR  
OPTICAL AMPLIFICATION OF APPARENT RATE OF  
REFLECTOR ROTATION IN Q-SWITCHING OF LASER  
RESONATOR A65-26946
- LIGHT OUTPUT FROM HELIUM-NEON GAS MASER  
PHOTOGRAPHED WITH AND WITHOUT INTRACAVITY  
MODULATION AT LOCKING FREQUENCY, USING HIGH SPEED  
ROTATING MIRROR A66-17205
- ROTATION  
CONCEPTUAL MODEL OF BACKSCATTERED FIELD OF LASERS  
AND USE FOR ROTATION DETECTION  
GE/EE/65-13 N66-16473
- RUBIDIUM  
THRESHOLD CONDITIONS FOR CONTINUOUS SELF-SUSTAINED  
OSCILLATIONS PRODUCED BY REGENERATIVE RUBIDIUM GAS  
MASER A65-17659
- SELF-SUSTAINED OSCILLATION OBTAINED IN OPTICALLY  
PUMPED RUBIDIUM MASER OPERATING AT TRANSITION  
FREQUENCY OF 6835 MC A65-21873
- OPTICALLY PUMPED RUBIDIUM 87 MASER OSCILLATOR  
A66-24124
- SELF-SUSTAINED RUBIDIUM 87 MASER OSCILLATOR  
N66-10395
- RUBY  
CHROMIUM INDUCED LIGHT DISPERSION IN R LINES OF  
RUBY, NOTING REFRACTION SHIFT IN LASER SPECTRUM  
A65-20260
- RUBY AS SUBMILLIMETER MASER MATERIAL, NOTING  
RELAXATION TIME AND TEMPERATURE CRITERIA  
A65-26821
- IMPROVEMENT OF CRYSTAL QUALITY OF FLAME FUSION  
RUBY - LASER MATERIAL  
AL-TDR-64-195, PT. I N65-15848
- GROWTH OF RUBY BOULES ON 60 DEGREE VERNEUIL RODS  
BY CZOCHRALSKI METHOD - LASER APPLICATION  
SRCR-65-1 N65-27885
- GROWTH OF BROAD LINEWIDTH RUBY SINGLE CRYSTALS  
FROM FLUX AND ADDITION OF GALLIUM FOR HIGH  
OPTICAL LASERS  
R-11-454 N65-28525
- TRAVELING WAVE MASER FOR DIRECT MEASUREMENT OF  
CHANGES IN RUBY SPIN TEMPERATURE FOR VARIOUS  
PERTURBATIONS  
NASA-CR-58815 N65-29444
- COMPUTER ANALYSIS DETERMINING CHANGE OF POPULATION  
INVERSION AND OUTPUT PHOTON FLUX AND EXPERIMENT  
USING RUBY FOR OSCILLATOR AND AMPLIFIER USING  
TRAVELING WAVE MASER IN TRIANGULAR CONFIGURATION  
GSP/PHYS/65-14 N65-31091
- RUBY CRYSTAL OPTICAL PROPERTIES INVESTIGATED BY  
INTERFERENCE RINGS FROM REFLECTING HE- NE LASER  
BEAM FROM CRYSTAL FACE A66-11045
- RUBY CRYSTAL OPTICAL PROPERTIES INVESTIGATED BY  
INTERFERENCE RINGS FROM REFLECTING HE- NE LASER  
BEAM FROM CRYSTAL FACE A66-23292
- VAPOR PHASE GROWTH OF RUBY SINGLE CRYSTALS FOR  
LASER APPLICATIONS  
AD-629154 N66-23875
- RUBY LASER  
RUBY LASER TEMPERATURE MEASUREMENT AND FILTERING  
BY DETERMINING SPECTRAL POSITION OF POLARIZATION  
INTERFERENCE BANDS A65-14184
- HYPERSONIC WAVES PRODUCED BY BRILLOUIN EFFECT,  
USING METHOD OF TWO INTENSE LIGHT BEAMS  
A65-14874

- PARAMETRIC DEPENDENCE OF TIME PROFILE, PEAK POWER AND NUMBER OF GIANT PULSES OF ROTATING PRISM Q-SWITCHED LASERS A65-15103
- R SUB 1 RUBY LINE EMISSION AND FREQUENCY DEPENDENCE ON TEMPERATURE VARIATION A65-15205
- STIMULATED EMISSION EVIDENCE FROM NITROGEN COOLED SPIKING RUBY-LASER-IRRADIATED DEGENERATED P-TYPE GA AS CRYSTALS A65-15323
- NOBLE GAS MOLECULAR SCATTERING OF RUBY LASER LIGHT COMPARED WITH RAYLEIGH THEORY A65-15438
- SINGLE PULSES OF ELECTRON EMISSION PRODUCED BY SPINNING-PRISM Q-SWITCHED RUBY LASER A65-15443
- NANOSECOND HEATING OF AQUEOUS SYSTEMS BY Q-SWITCHING ROTATING PRISM RUBY LASER A65-15788
- OPTICAL MIXING OF NITROBENZENE RAMAN RUBY LASER LIGHT IN ADP AND OTHER NONLINEAR DIELECTRIC MEDIA A65-15951
- PULSED RUBY LASER ROD CAVITY LOSS MEASUREMENTS FROM 77 TO 293 DEGREES K INDICATING ESSENTIALLY CONSTANT LOSS A65-16129
- OPTICAL AND LASER THRESHOLD MEASUREMENTS ON 39 FLAME-FUSION RUBIES TO OBTAIN HIGHEST OPTICAL QUALITY LASER RODS A65-16402
- ELECTRICAL SWITCHING OF EMISSION DIRECTION OF LASER OSCILLATOR BY INTERNAL DEFLECTION OF LASER BEAM A65-16403
- AXIALLY UNIFORM ENERGY DENSITY IN LASER CAVITY OBTAINED, USING BIREFRINGENT SAPPHIRE QUARTER WAVE PLATES, RUBY ROD AND TWO MIRRORS A65-16407
- OPTICAL PUMP PULSE SHAPE EFFECT ON POPULATION INVERSION ATTAINED IN RUBY LASER A65-16569
- STIMULATED BRILLOUIN RADIATION IN OFF-AXIS RUBY LASER RESONATOR USING CARBON DISULFIDE CELL, EXAMINING OUTPUT SPECTRUM A65-16811
- RUBY LASER AMPLIFIER ENERGY INPUT-OUTPUT MATHEMATICAL ANALYSIS AND EXPERIMENTAL VERIFICATION A65-17648
- RUBY LASER POWER DEPENDENCE ON FREQUENCY SPLITTING OF TWO COMPONENTS OF R1 DOUBLET AT 77 DEGREES K A65-17654
- EMISSION AND ABSORPTION PROFILES FOR RUBY R SUB 1 LINES SHOW ABSENCE OF SIGNIFICANT STOKES SHIFT A65-17664
- RUBY LASER CRYSTAL FLAWS OF CLOSELY PACKED SPHEROIDS SUGGESTING PLASTIC FLOW AND QUENCH-IN AS CAUSE A65-17684
- CO-60 GAMMA IRRADIATION INDUCED ENERGY OUTPUT INCREASE OF RUBY LASER CRYSTAL A65-17687
- PULSED RUBY LASER OUTPUT MEASUREMENT BY OPTICAL BOLOMETER A65-18017
- INDUSTRIAL APPLICATION OF RUBY AND NEODYMIUM LASERS INCLUDE SUPERHARD MATERIAL MACHINING AND METALLURGY A65-18120
- HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE EXCITATION AND GENERATION KINETICS IN RUBY LASER WITH CONCENTRIC CAVITY A65-18460
- CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL RUBY CRYSTALS DUE TO HEATING BY EXCITING LIGHT A65-18461
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING TOTAL REFLECTION PRISM A65-18462
- TIME DEPENDENT VARIATION OF RUBY LASER STIMULATED EMISSION INTENSITY A65-19074
- WATER COOLED RUBY LASER CONTINUOUSLY OPERATED AT ROOM TEMPERATURE USING ROD IN PUMPING CAVITY A65-19234
- RUBY-LASER ROD HOMOGENEITY DETERMINATION BY INTERFEROMETERS A65-19569
- STIMULATED RAMAN EFFECT OF BENZENE USING RUBY LASER, EXAMINING OUTPUT SPECTRUM, THRESHOLD POWER AND EFFICIENCY AT STOKES LINES A65-19598
- THOMSON SCATTERED LASER RADIATION USED TO DETERMINE ELECTRON DENSITY IN HELIUM PLASMA, EXAMINING THYRATRON TUBE AND VOLTAGE PROBE USE A65-19618
- QUASI-CONTINUOUS EMISSION OR REGULAR RELAXATION OSCILLATIONS FROM MANY-ELEMENT RUBY LASER OPERATING IN VERY FEW AXIAL MODES A65-19619
- RUBY LASER OSCILLATIONS MODULATED BY ULTRASONIC VIBRATION A65-19623
- ENERGY MEASUREMENT OF RUBY LASER INDUCED ELECTRON EMISSION FROM TUNGSTEN A65-20241
- RUBY LASER THRESHOLD PUMPING AND EMISSION ENERGIES RELATED TO TRANSMISSION COEFFICIENT, ROD DIAMETER AND THRESHOLD LEVEL A65-20343
- EMISSION SPECTRUM OF RUBY LASER WITH EXTERNAL SPHERICAL MIRRORS IN NONDAMPING INTENSITY FLUCTUATIONS AND QUASI-STEADY GENERATION A65-21041
- RUBY LASER OUTPUT RADIATION CHANGE DUE TO PHTHALOCYANINE SOLUTIONS PLACED IN RESONATOR CAVITY A65-21071
- SUPPRESSING PULSED LASER SPIKING BY PROVIDING EQUILIBRIUM PHOTON DENSITY AS THRESHOLD IS REACHED, NOTING CASE OF RUBY LASER A65-21300
- REFLECTED RADIATION OF Q-SPOILED RUBY LASER FROM EXPLORER XXII A65-21306
- EFFECT OF PARTIALLY SHIELDING RUBY LASER ROD FROM PUMP LIGHT UPON LONGITUDINAL MODE SPECTRA OF LASER A65-21657
- LIGHT INTENSITY DISTRIBUTION INSIDE CYLINDRICAL REFLECTING CAVITY USING RUBY LASER ROD AND ANALYSIS OF INTERDEPENDENCE OF THRESHOLD, FILAMENT POSITION AND EFFICIENCY A65-22624
- IMMERSION LIQUIDS FOR HIGH ENERGY RUBY LASERS WITH MATCHING REFRACTIVE INDEXES TRANSPARENT AT RUBY PUMPING AND LASING WAVELENGTHS A65-22625
- TIME DEPENDENCY OF INTENSITY OF STIMULATED EMISSION IN RUBY LASER WITH OPTICAL RESONATOR CONTAINING ALUMINUM-COATED OPAQUE SPHERICAL MIRRORS A65-23014
- PRODUCTION OF ION VELOCITIES OVER 4 KM/SEC BY FOCUSED RUBY LASER MAKES PRACTICAL APPLICATION IN DIRECT THRUSTORS AND AS PLASMA SOURCE IN ACCELERATOR TYPE THRUSTORS A65-23626
- PARAMETRIC GAIN ACCOMPANYING PARAMETRIC AMPLIFICATION OF LIGHT BEAM BY SECOND HARMONIC FREQUENCY OF STIMULATED RADIATION FROM RUBY LASER ADP CRYSTALS A65-24280
- RESONANCE OSCILLATION IN RUBY LASER EMISSION STUDIED BY FABRY-PEROT MULTIPLEX ETALON AS FUNCTION OF RESONATOR PROPERTIES A65-24976
- LASER BEAM MACHINING AND DRILLING TECHNIQUES FOR USE ON ANY MATERIAL REGARDLESS OF THERMAL PROPERTIES A65-25373

# SUBJECT INDEX

# RUBY LASER CONT

RUBY LASER ROD POSITION ALONG INTERFEROMETER AXIS,  
DETERMINING PRESENCE OF ADJACENT INTERFEROMETER  
MODES A65-25874

FREQUENCY SEPARATION BETWEEN TRANSVERSE MODES OF  
RUBY LASER MEASURED BY FABRY-PEROT  
INTERFEROMETER AND VERIFIED BY TRANSVERSE MODE  
SELECTION A65-27610

RAMAN DIFFUSION OF LIQUIDS PLACED OUTSIDE OPTICAL  
CAVITY AND EXCITED BY RUBY LASER A65-27944

E-LEVEL POPULATION IN RUBY ROD AS FUNCTION OF PUMP  
ENERGY EMITTED BY FLASH TUBE A65-28013

HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE  
EXCITATION AND GENERATION KINETICS IN RUBY LASER  
WITH CONCENTRIC CAVITY A65-28089

CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL  
RUBY CRYSTALS DUE TO HEATING BY EXCITING LIGHT  
A65-28090

RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING  
TOTAL REFLECTION PRISM A65-28091

OPTICAL BEAM DIVERGENCE OF 6943 ANGSTROM LIGHT  
CAUSED BY SINGLE PASS THROUGH RUBY LASER AMPLIFIER  
DURING PUMPING A65-29529

POLARIZATION EFFECTS IN RUBY LASER CONSISTING OF  
RIGHT-ANGLE ROOF-TOPPED ROD WITH C AXIS  
PERPENDICULAR TO ROOF EDGE, EXTERNAL MULTILAYER  
DIELECTRIC REFLECTOR AND HELICAL FLASH TUBE  
A65-29530

SECOND HARMONIC EMISSION AND DIFFRACTION PHENOMENA  
IN KDP CRYSTAL EXCITED BY RUBY LASER BEAM  
A65-29559

STABILITY OF CORRECTED COUPLED-MODE LASER EQUATION  
DERIVED FROM MODEL FOR RUBY LASER SPIKING  
RESULTING FROM MODE INTERFERENCE A65-29805

NATURAL SELECTION OF MODES USING PASSIVE Q-SWITCH  
IN GIANT PULSE RUBY LASER WHICH NARROWS OUTPUT  
SPECTRUM A65-29850

SINGLE AXIAL MODE OPERATION OF RUBY LASER AT ROOM  
TEMPERATURE, USING SATURABLE FILTER Q-SWITCH AND  
RESONANT REFLECTOR A65-29852

NOISE TEMPERATURE MEASUREMENT OF RUBY MASER,  
CONSIDERING GAIN STABILITY AND BANDPASS WIDTH  
A65-30378

RUBY LASER OUTPUT RADIATION CHANGE DUE TO  
PHthalocyanine SOLUTIONS PLACED IN RESONATOR  
CAVITY A65-31236

H F MODULATION OF RADIATION SPIKES DUE TO BEATS  
BETWEEN OSCILLATION MODES IN OPTICAL RUBY LASER  
A65-31701

LASER OPERATION PRINCIPLES AND OSCILLATING ELEMENT  
OF LASER RESONATOR A65-31880

OBSERVED AND PREDICTED EFFICIENCY OF CONVERSION OF  
RADIATION FROM GIANT PULSE RUBY LASER INTO  
STIMULATED RAMAN SCATTERING A65-32209

LASER RANGEFINDER DEVICE PROVIDES FAST AND  
ACCURATE RANGE OF NONCOOPERATIVE TARGETS OPERATING  
ON RADAR PRINCIPLE A65-32586

ZEEMAN EFFECT IN PARAMAGNETIC CRYSTALS BY RUBY FOR  
MICROWAVE MODULATION OF PULSED LASER BY ABSORPTION  
A65-32746

SIMULTANEOUS LASER OSCILLATION OBSERVED AT 6943  
AND 6929 ANGSTROM WAVELENGTHS IN NORMAL AND Q-  
SPOILED OPERATION OF RUBY LASER A65-32748

LASER BIBLIOGRAPHY / JUNE TO DECEMBER 1964/  
A65-32749

EFFECT OF NONUNIFORM SPATIAL INTERACTION BETWEEN  
MODES ON TEMPORAL AND SPATIAL OUTPUT OF RUBY LASER  
A65-33415

LOW ANGLE SCATTERING AND INTERFEROGRAPHIC  
MEASUREMENTS USED IN EVALUATING RUBY LASER RODS  
A65-33416

CHROMIUM ALIGNMENT IN RUBY BY OPTICALLY PUMPING  
RUBY SAMPLE WITH CIRCULAR POLARIZED RADIATION FROM  
RUBY LASER A65-33418

OSCILLATION CHARACTERISTICS OF RUBY LASER WITH  
EXTERNAL MIRRORS OF LARGE SPACING A65-33517

GIANT RUBY LASER PULSE PRODUCTION FROM RAPID  
SATURATION OF DYE ABSORBER SOLUTION IN OPTICAL  
CAVITY BY SINGLE-SINGLETON TRANSITIONS A65-33521

SELECTIVE REFLECTION AND DISPERSION PATTERNS NEAR  
RED RUBY LINES, USING RUBY LASER AS LIGHT SOURCE  
A65-33587

Q-SPOILED RUBY LASER BEAM FOCUSED ON GRAPHITE,  
OBTAINING SWAN EMISSION OF CARBON MOLECULE  
A65-34207

FLUORESCENCE FROM CALCIUM SULFIDE EXCITED BY RUBY  
LASER COMPARED WITH PHOTOCONDUCTIVITY INDUCED BY  
ORDINARY GREEN LIGHT TO SUPPORT DOUBLE PHOTON  
ABSORPTION MECHANISM A65-34665

EMISSION CHARACTERISTICS OF Q-SWITCHED RUBY LASER  
WITH SATURABLE ABSORBER A65-35053

MODE LOCKING EFFECTS IN INTERNALLY KDP MODULATED  
RUBY LASER A65-35063

STIMULATED EMISSION FROM CHROMIUM IONS IN Q-  
SPOILED RUBY LASER A65-35066

HIGH SPEED PHENOMENA HOLOGRAMS PRODUCED BY  
RADIATION FROM PULSED RUBY LASER OPERATED EITHER  
IN Q-SWITCHED OR CONVENTIONAL MODE A65-35067

THERMAL DISTORTION, EXPANSION AND SCATTERING IN  
RUBY AND GLASS LASER RODS DURING AND AFTER PUMP  
FLASH A65-35068

ACTIVE AND PASSIVE Q-SWITCHES FOR INCREASING  
STORED PUMPING ENERGY OF LASERS AND INHIBITING  
RESONANCE FOR SUBSEQUENT PUMP LASER EXCITATION AND  
DISCHARGE A65-35118

BEAM DIVERGENCE AND FAR-FIELD PATTERNS OF RUB RODS  
OF VARYING OPTICAL QUALITY A65-35315

EFFECTS OF RESONATOR LENGTH AND MIRROR  
TRANSPARENCY AND ALIGNMENT UPON DYNAMIC AND STATIC  
CHARACTERISTICS OF RUBY LASER WITH MODULATED  
Q-FACTOR A65-35786

INDUCED RADIATION IN GaAs SEMICONDUCTOR CRYSTAL  
EXCITED BY RUBY LASER WITH Q-MODULATION  
A65-35842

RUBY LASER NOISE RADIATION CONSISTING OF INCREASED  
LUMINESCENCE AND LATERALLY DISPERSED GENERATION  
DETERMINED FROM ENERGY LEVEL POPULATIONS  
A65-35863

CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY  
SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY  
LASER A65-35866

TRUNCATED EQUATIONS DESCRIBING COHERENT RADIATION  
OF EXCITED CHROMIUM IONS IN RUBY SITUATED IN  
TRAVELING WAVE RESONATOR A65-35919

RADIATION SCATTERING FACTOR DETERMINATION FOR RUBY  
LASER A65-36013

POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY  
ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR  
A65-36058

- INDUCED RADIATION AND LASER ACTION OF GALLIUM ARSENIDE SINGLE CRYSTAL EXCITED BY LIGHT FROM Q-MODULATED RUBY LASER A65-36362
- PHOTON TRANSPORT AND POPULATION INVERSION IN ACTIVE MEDIUM WITH PUMPING EFFECT, CONSIDERING INTENSE BEAM INCIDENCE AND RUBY LASER A65-36712
- CAUSES OF LASER DAMAGE TO OPTICAL COMPONENTS PE-TR-7735 N65-14185
- OPTICAL PARAMETRIC AMPLIFICATION INVOLVING THREE WAVES, OPERATION OF HIGH POWER, NEARLY SINGLE MODED RUBY LASER, AND OBSERVATION OF PARAMETRIC INTERACTION AMONG RAMAN-SHIFTED LINES RADC-TDR-64-386 N65-14311
- PHOTOTUBE OBSERVATION OF RUBY LASER OUTPUT AS FUNCTION OF TIME N65-15570
- ENERGY OUTPUT INCREASE OF RUBY LASER CRYSTAL SYSTEMS BY NUCLEAR ENERGY, LASER CRYSTAL GROWTH, AND SURFACE FINISH DEVELOPMENT AD-455571 N65-17595
- GAMMA RADIATION EFFECT ON ENERGY OUTPUT OF RUBY LASER CRYSTALS N65-17596
- PARAMETRIC AMPLIFICATION IN ADENOSINE DIPHOSPHATE USING SECONDARY HARMONIC PRODUCED BY RUBY LASER RADC-TDR-64-484 N65-18629
- RUBY LASER MODULATION AT ATOMIC LEVEL - FREQUENCY SHIFT MEASUREMENT OF LASER EMISSION UNDER INHOMOGENEOUS MAGNETIC FIELD BY SPECTROSCOPY NASA-CR-57464 N65-19863
- GAS IONIZATION IN FOCUSED RUBY LASER BEAM N65-21219
- FOCUSING AND COLLIMATION PROPERTIES OF PULSED MULTIMODING RUBY LASER REPT.-1579-19 N65-21554
- BREAKDOWN OF ARGON BY NEODYMIUM AND RUBY LASER PULSES REPT.-1935-1 N65-22072
- SPECTRAL LINE WIDTH NARROWING OF PULSED TRAVELING WAVE RUBY LASER OUTPUT AD-610865 N65-22139
- GAS IONIZATION PHENOMENON AT OPTICAL AND INFRARED FREQUENCIES - RUBY LASER INDUCED IONIZATION, FOCUSED SPOT DIAMETER, BREAKDOWN EMISSION, AND IONIZATION TIMES AND NONATTENUATION RADC-TR-64-568 N65-22250
- RUBY LASER WITH VIBRATING MIRROR FOR STUDY OF TEMPORAL OUTPUT MEASUREMENTS N65-22759
- TRIGGERING OF BREAKDOWN OF NOBLE GASES SUBJECTED TO RUBY LASER RADIATION BY MULTIPHOTON IONIZATION REPT.-1935-3 N65-22851
- RUBY LASER FIELD PATTERNS - DIFFRACTION PATTERNS TR-1 N65-22896
- RUBY LASER Q-SWITCHING USING PASSIVE SOLID STATE OR LIQUID ORGANIC BLUE DYE TO-B-64-15 N65-22933
- PHOTOCHEMICAL BEHAVIOR OF METAL PHTHALOCYANINES IN PRODUCING GIANT PULSES FROM RUBY LASER N65-23435
- RUBY AND NEODYMIUM GLASS LASERS FOR INDUSTRY - ELECTRONICS N65-23722
- ELECTRON BEAM MELTING HEAT SOURCE IN VACUUM METALLURGY, AND RUBY AND NEODYMIUM GLASS LASERS FOR INDUSTRY N65-23723
- FOUR-LEVEL, GAS, LIQUID, SEMICONDUCTOR, AND RUBY LASERS RSIC-195 N65-24836
- RELAXATION OSCILLATIONS IN EMISSION OF RUBY LASERS UNDER VARIOUS OPERATIONAL CONDITIONS T-G-215 N65-24968
- IMAGE FORMING IN ATMOSPHERIC SCATTERING MEDIUM WITH 60 NANOSECOND ILLUMINATING PULSE FROM Q-SWITCHED RUBY LASER AFAL-TR-64-278 N65-25580
- COMPARISON OF UNDERWATER ATTENUATION OF RUBY LASER LIGHT WITH NCNLASER LIGHT NRL-6181 N65-28158
- EFFECT OF OPTICAL PUMPING ON ANOMALOUS DISPERSION IN SELECTED RUBY LASERS AND VARIATION OF REFRACTIVE INDEX DURING LASER OPERATION SATR-3 N65-28619
- LASER RESEARCH DEALING WITH EFFECT OF PUMPING ON RUBY QUALITY, LANTHANUM FLUORIDE EXAMINATION, LARGE RUBY LASER RODS, DC OPERATION OF MERCURY TUBE, HOLOGRAMS, AND LASER PHYSICS NRL-MR-1604 N65-28920
- GASEOUS AND RUBY LASERS AS LIGHT SOURCES FOR PHOTOELASTICITY TEAM-276 N65-29794
- SUN-POWERED LASER TRANSMITTER DEVELOPMENT - RUBY, NEODYMIUM-DOPED GLASS, AND NEODYMIUM-DOPED CALCIUM TUNGSTATE LASER MATERIALS IER-1 N65-29901
- ABSORPTION COEFFICIENT OF RUBY LASER RADIATION IN FULLY IONIZED LIGHT ELEMENTS IPP-6/27 N65-30178
- RUBY LASER IN OPTICAL RADAR PROBE SYSTEM FOR BALLOON SOUNDING OF STRATOSPHERIC AEROSOL N65-30205
- OPTICALLY PUMPED SEMICONDUCTOR LASER IN U.S.S.R. N65-30208
- THEORY AND APPLICATION OF MASERS AND LASERS - CESIUM, HELIUM-NEON, AND RUBY MASER OSCILLATOR SYSTEMS N65-31361
- Monte CARLO METHOD FOR CALCULATION OF EFFECTIVE FLUORESCENT LIFE TIMES FOR RUBY LASER RODS WITH BREWSTER ANGLE ENDS AND ROUGHENED SIDES UCRL-7765-T/REV. 1/ N65-32343
- GIANT RADIO TELESCOPE TO DETECT EXTRATERRESTRIAL RADIATION, RAMAN SCATTERING LASERS, FORECASTING SOLAR FLARES FOR MANNED SPACE FLIGHT, VOSKHOD II LIFE SUPPORT, AND ALUMINUM NITRIDE FILMS N65-32675
- RAMAN SCATTERING LASERS N65-32677
- MOLECULAR SCATTERING OF LIGHT USING RUBY LASER SOURCE CEA-R-2375 N65-32985
- RADIATION PULSES FROM RUBY OPTICAL QUANTUM GENERATOR DURING SINGLE IGNITION FTD-TT-65-134/1&2 N65-33409
- EXPERIMENTS ON OPERATING LIFE AND TRANSVERSE MODE HOPPING IN CONTINUOUS WAVE RUBY LASER IER-7 N65-33421
- STIMULATED BRILLOUIN SCATTERING OF INTENSE LASER LIGHT WITH BUILD-UP OF COHERENT HYPERSONIC WAVES IN LIQUIDS NASA-CR-58214 N65-33710
- UNSTABLE OPTICAL RESONATORS FOR RUBY LASER APPLICATIONS ML-1227 N65-33916
- SODIUM-MERCURY METAL VAPOR LASER SP/PH/65-15 N65-33995
- USE OF LASERS FOR MEASUREMENT OF DISTANCE, ANGLE, HEIGHT, AND GEODETIC SURVEYING JPRS-32185 N65-34192

# SUBJECT INDEX

# RUBY LASER CONT

- EXCITED STATE SPECTROSCOPY USING RUBY LASER AND  
LOCALIZED EXCITONS IN ALKALI HALIDES  
AD-619198 N65-35423
- OPTICAL RECTIFICATION IN CRYSTALS USING RUBY  
LASER BEAM  
TID-21807 N65-35445
- MICROWAVE FREQUENCY BEATS IN OFF-AXIS MODES OF  
RUBY LASERS  
TR-3 N65-35553
- REGENERATIVE RUBY LASER AMPLIFIERS AT LIQUID  
NITROGEN TEMPERATURES  
ECOM-2575 N65-35642
- SPATIAL DISTRIBUTION OF ELECTRICAL FIELD OBTAINED  
BY FOCUSING RADIATION OF RUBY LASER  
A66-10250
- DESTRUCTIVE AND LUMINESCENCE EFFECTS OF FOCUSED  
RUBY LASER BEAM ON RUBY  
A66-10265
- RUBY LASER OUTPUT EXHIBITING REGULAR SPIKES  
A66-10324
- RUBY LASER RADIATION EFFECT ON FLUORESCENCE AND  
LASER ACTION IN DYSPROSIUM DOPED CALCIUM FLUORIDE  
CRYSTALS  
A66-10718
- RUBY LASER WITH CONCENTRIC RESONATOR AS  
ILLUMINATION SOURCE OF BUBBLE CHAMBER  
A66-11189
- GENERAL PROGRESS OF SEMICONDUCTOR JUNCTION AND  
RUBY LASERS, ESPECIALLY IN EXPERIMENTAL FIELD  
A66-11370
- OPTICAL PATH LENGTH CHANGE MEASURED THROUGH LASER  
RODS WITHIN PUMPING PERIOD BY INTERFEROMETRIC  
TECHNIQUE  
A66-11376
- EXCITATION OF RUBY LASERS USING DOUBLE-PUMPED  
HIGH-INTENSITY HELICAL FLASH TUBES, OBTAINING  
TIME-RESOLVED SPECTRA OF ELECTRICAL DISCHARGES AND  
PLASMA TEMPERATURES  
A66-11446
- TRAVELING WAVE OSCILLATIONS IN RUBY LASER  
RESONATOR USING PASSIVE OPTICAL ISOLATOR,  
ELIMINATING FARADAY ROTATOR AND ATTENDANT  
MAGNETIC FIELD  
A66-11448
- OPTICAL WHISPERING MODE OF POLISHED CYLINDERS AND  
IMPLICATION IN LASER TECHNOLOGY, NOTING TRAPPED  
FLUORESCENT LIGHT  
A66-12203
- COHERENCE THEORY FOR COLLIMATION AND FOCUSING OF  
TIME-AVERAGED INTENSITY OF PULSED MULTIMODE LASER  
RADIATION  
A66-12205
- MAGNIFICATION OF SMALL RAY DEVIATIONS CAUSED BY  
REFRACTIVE INHOMOGENEITIES IN LARGE RUBY RODS  
WITH BREWSTER-ANGLE ENDS  
A66-12217
- CUT-OFF OF RUBY LASER EMISSION BY PULSED ELECTRON  
AND BREMSSTRAHLUNG RADIATION, USING ADIABATIC  
TEMPERATURE  
A66-12447
- OUTPUT POWER AND PULSE DURATION OF RUBY LASER  
A66-12602
- MULTIPLE LIGHT FILTER NARROWING EMISSION BANDS OF  
RUBY LASER WITH MULTIPLEX RESONATOR  
A66-12627
- BIOLOGICAL EFFECTS OF LASER RADIATION WITH  
REFERENCE TO INTACT ANIMALS, PRIMATE EYES AND SKIN  
AND MALIGNANT TUMORS OF ANIMAL AND HUMAN ORIGIN  
A66-12994
- INTERNAL BUBBLE FORMATION AND CRACKING IN RODS OF  
Q-SWITCHED RUBY AND ND-GLASS LASERS CAUSED BY  
LASER LIGHT, AND IN CASE OF ND-GLASS RODS, BY  
PLATINUM INCLUSIONS IN GLASS  
A66-13002
- MAGNITUDE OF ANISOTROPIC LINE BROADENING IN RUBY  
A66-13278
- DESTRUCTIVE AND LUMINESCENCE EFFECTS OF FOCUSED  
RUBY LASER BEAM ON RUBY  
A66-13310
- UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE  
RUBY LASER TECHNIQUES, PRESENTING HEIGHT  
DISTRIBUTION CURVES OF SCATTERED LIGHT  
A66-13376
- RUBY LASER CRYSTALS GROWN BY FLAME-FUSION, FLUX  
AND CZOCHRALSKI METHOD EXAMINED FOR PERFECTION BY  
X-RAY TOPOGRAPHY AND DOUBLE-CRYSTAL ROCKING  
CURVES  
A66-13744
- PARALLEL GROOVES AS SURFACE DAMAGE IN  
SEMICONDUCTORS PRODUCED BY RUBY LASER AS  
DIFFRACTION EFFECT  
A66-13753
- CC S SINGLE CRYSTAL OPTICAL GENERATOR DURING  
EXCITATION BY RUBY LASER, DISCUSSING TWO-PHOTON  
ABSORPTION COEFFICIENT AT 300 DEGREES K FOR  
RADIATION FLUX DENSITIES  
A66-13874
- CONICAL EMISSION IN RUBY LASERS WITH EXTERIOR  
MIRRORS  
A66-14278
- MODES OF EMISSION-VS-TIME SPECTRUM, OPTICAL  
EMISSION SPECTRUM AND SUPERPOSITION SPECTRUM OF  
SHORT CONFOCAL RUBY LASER IN NEAR FIELD  
A66-14290
- SPATIAL DISTRIBUTION OF HOLLOW-CONE SHAPED  
EMISSION OF MODES WHICH ARE TOTALLY REFLECTED IN  
NEODYMIUM-GLASS LASERS  
A66-14291
- MODE SELECTIVE CHARACTERISTICS OF PLANE-PARALLEL  
DIELECTRICAL PLATE AS REFLECTOR FOR RUBY LASER  
RESONATOR  
A66-14330
- SPIKEFREE EMISSION FROM LASER USING LONG RUBY  
CRYSTAL DOPED HEAVILY WITH CHROMIUM AND SUITABLE  
SYMMETRY FOR PUMP RADIATION  
A66-14331
- MODE OF OPERATION OF VARIOUS RUBY LASERS WITH  
PLANE-PARALLEL MIRRORS AT ROOM TEMPERATURE  
A66-14500
- LASER DIGITAL DEVICES, EXAMINING QUENCHING OF GAIN  
AND OPTICAL ABSORPTION  
A66-14826
- RUBY LASERS DISCUSSING OUTPUT CHARACTERISTICS,  
BEAM DIVERGENCE, BEAT MODES AND RESPECTIVE  
EXPERIMENTAL TECHNIQUES  
A66-14919
- PHOTOGRAPHIC FILM USED FOR QUANTITATIVE  
MEASUREMENTS OF INTENSITY DISTRIBUTION IN Q-  
SWITCHED LASER BEAM  
A66-14920
- TIME DEPENDENT EMISSION BEHAVIOR OF RUBY LASER  
DISCUSSING RATE EQUATIONS, Q-VALUE, OUTPUT POWER,  
STEADY STATE VALUES, ETC  
A66-14981
- SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION  
PROPERTY CHANGES DUE TO PULSED RUBY LASER  
RADIATION  
A66-15354
- POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY  
ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR  
A66-15861
- VARIATION OF SCATTERING CROSS SECTION WITH BEAM  
INTENSITY FOR RUBY LASER LIGHT ON ATOMIC HYDROGEN  
A66-15864
- DISPERSION RESONATOR PERFORMANCE IN RUBY LASER,  
SHOWING GENERATION OF R SUB 1 AND R SUB 2 LINES  
A66-16346
- HYDROGEN MOLECULE MULTIPHOTON IONIZATION,  
DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY  
RUBY LASER EMISSION  
A66-16517
- RUBY LASER NOISE RADIATION CONSISTING OF INCREASED  
LUMINESCENCE AND Laterally DISPERSED GENERATION  
DETERMINED FROM ENERGY LEVEL POPULATIONS  
A66-16628
- OPTICAL DESIGN OF ELLIPTICAL CAVITIES AND  
COMPARISON OF ENERGY TRANSFERS FROM LIGHT SOURCE  
TO RUBY LASER WITH CYLINDRICAL CAVITIES  
A66-16647

LIFE PERFORMANCE CHARACTERISTICS OF UNCOATED RUBY LASER Q-SWITCHED BY ROTATING PRISM FORMING END REFLECTOR OF LASER RESONATOR A66-16675

GROUND STATE ESR SATURATION EFFECT ON RUBY LASER OUTPUT FREQUENCY AT CRYOGENIC TEMPERATURE A66-16753

FUSED SILICA OUTPUT COUPLING COMPONENT FOR LASER SYSTEM, USING FRUSTRATED TOTAL INTERNAL REFLECTION CONFIGURATION A66-17287

Q-SWITCHED OPTICAL MASER SYNCHRONIZATION, DISCUSSING EXPERIMENTAL DESIGN, SETUP AND PERFORMANCE A66-17297

OSCILLATION SPIKES IN QUASI-CONTINUOUS OPERATION OF RUBY LASER AT ROOM TEMPERATURE, NOTING THRESHOLD PUMPING ENERGY A66-17532

CONCENTRATION AND TEMPERATURE DEPENDENCE OF SPIN-LATTICE RELAXATION TIME IN RUBY AT HELIUM TEMPERATURES A66-18257

TIME RESOLUTION OF ELECTRON AND ION EMISSION PRODUCED BY Q-SWITCHED RUBY LASER PULSE FOCUSED ON METAL SURFACE A66-18358

PHOTON ECHO, SHORT PULSE OF LIGHT SPONTANEOUSLY EMITTED BY DILUTE RUBY CRYSTAL AFTER RUBY-LASER PULSE IRRADIATION A66-18442

THERMOSTIMULATED INDUCED ELECTRON EMISSION FROM SAMPLES CUT FROM LASER RUBY CRYSTALS DETECTED WITH OPEN POINT COUNTER A66-18609

CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY LASER A66-19269

DECAY OF F-CENTER EXCITATIONS IN ALKALI HALIDES INDUCED BY SHORT INTENSE PULSE OF Q-SWITCHED RUBY LASER A66-19367

GENERATION IN CADMIUM SULFIDE DURING TWO-PHOTON OPTICAL EXCITATION BY RUBY LASER WITH MODULATED Q-FACTOR A66-19620

EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING SPECTRAL RANGE, DURATION, ELECTRON EXCITATION MECHANISM AND UPPER WAVELENGTH LIMIT A66-19667

ACCURATE TRACKING OF BEACON- EXPLORER ORBITING OPTICAL REFLECTORS, USING PULSED RUBY LASER BEAMS A66-19902

H F MODULATION OF RADIATION SPIKES DUE TO BEATS BETWEEN OSCILLATION MODES IN OPTICAL RUBY LASER A66-19955

LOWER ATMOSPHERIC DENSITY MEASUREMENTS THROUGH LIGHT SCATTERING FROM Q-SPOILED RUBY LASER BEAM, USING OPTICAL RADAR DETECTOR A66-20398

TIME DEPENDENT EMISSION BEHAVIOR OF SINGLE AXIAL MODE OF DIFFRACTION LIMITED RUBY LASER AT ROOM TEMPERATURE A66-20420

INTENSE UV PUMPING EFFECT ON RUBY LASER OUTPUT A66-20519

OPTICAL DOUBLE RESONANCE IN RUBY, DISCUSSING ABSORPTION TRANSITIONS FROM LOWEST EXCITED STATE OF CHROMIUM ION EFFECTED BY LASER PUMPING A66-20856

SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION PROPERTY CHANGES DUE TO PULSED RUBY LASER RADIATION A66-20895

HYDROGEN MOLECULE MULTIPHOTON IONIZATION, DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY RUBY LASER EMISSION A66-20898

CONCENTRATION AND TEMPERATURE DEPENDENCE OF SPIN-LATTICE RELAXATION TIME IN RUBY AT HELIUM TEMPERATURES A66-20901

ROOM TEMPERATURE QUASI-CONTINUOUSLY PUMPED RUBY GIANT PULSE LASER WITH SATURABLE ABSORBER Q-SWITCH A66-21248

DIELECTRIC CAVITY MASER COMPOSED OF RUBY ROD SEPARATING METAL PLATES, NOTING STRENGTH SATURATION BEHAVIOR, POWER OUTPUT, ETC A66-21308

PUMP POWER DEPENDENCE OF RUBY LASER STARTING AND STOPPING TIME PREDICTED VIA RATE EQUATION ANALYSIS A66-21309

SPONTANEOUS EMISSION NOISE PROPERTIES OF PAIR OF PULSED RUBY LASER AMPLIFIERS A66-21310

SPIKING BEHAVIOR OF MULTIMODE RUBY LASER IN SPHERICAL RESONATOR, INTERPRETING NEAR-FIELD PATTERNS, FREQUENCY SPECTRUM, ETC A66-21311

LASER SIMULATED NUCLEATION IN BUBBLE CHAMBER, COMPARING SENSITIVITY WITH RADIOACTIVELY STIMULATED NUCLEATION A66-21583

EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING SPECTRAL RANGE, DURATION, ELECTRON EXCITATION MECHANISM AND UPPER WAVELENGTH LIMIT A66-21834

MULTIPHOTON IONIZATION OF XENON ATOM IN POWERFUL ELECTRIC FIELD BY RUBY LASER RADIATION A66-21966

MEASUREMENT OF RADIATION PATTERN OF RUBY LASER EMISSION FOR VARIOUS RESONATORS AND OPERATING REGIMES, NOTING LASER EFFECT ON ANGULAR HALF-WIDTH VALUES A66-22028

MULTIPLEX LIGHT FILTER FOR EXCITATION OF RUBY LASER A66-22032

DISPERSION RESONATOR PERFORMANCE IN RUBY LASER, SHOWING GENERATION OF R SUB 1 AND R SUB 2 LINES A66-22345

RUBY LASER AMPLIFIER AT LIQUID-NITROGEN TEMPERATURE TREATED AS THREE-MEDIUM TRANSMISSION SYSTEM, NOTING GAIN CHANGE WITH NEGATIVE ATTENUATION A66-22867

RUBY LASER WITH CONCENTRIC RESONATOR AS ILLUMINATION SOURCE OF BUBBLE CHAMBER A66-24010

BALANCED MIXER ACTION FOR OPTICAL HETERODYNING, USING MAGIC-T OPTICAL MIXER A66-24153

RUBY LASER OPTICAL RADAR DETECTION OF UPPER ATMOSPHERIC BACKSCATTERING A66-24395

SPATIALLY INDEPENDENT LASER RATE EQUATION GENERALIZED FOR MULTIMODE EFFECTS, NOTING STEADY STATE OSCILLATION THRESHOLD SINGULARITIES, SPIKING PARAMETERS, ETC A66-24560

STEADY STATE VALUE OF INVERTED POPULATION, POWER OUTPUT, THRESHOLD BEHAVIOR AND SPIKING CHARACTERISTICS FOR SINGLE-MODE LASER WHEN RADIATION INTENSITY HAS SPATIAL DEPENDENCE A66-24562

RUBY LASER FOR STUDY OF LASER RADIATION EFFECTS ON BIOLOGICAL ORGANISMS GR-3885 N66-10583

MECHANISMS ASSOCIATED WITH ELECTRICAL BREAKDOWN AND IONIZATION IN GAS CAUSED BY HIGH-INTENSITY RUBY OR NEODYMIUM LASER ILLUMINATION D-920272-4 N66-11453

INFLUENCE OF RESONANT CAVITY, XENON LIGHT, AND OTHER PARAMETERS ON RUBY LASER EMISSION ENERGY OUTPUT FTC-TT-64-1339/1626364 N66-11522

EFFECT OF RUBY LASER ENERGY ON GAMMA RADIATED HUMAN ADENOCARCINOMA CELLS SAM-TR-65-41 N66-11874

# SUBJECT INDEX

## SCALE MODEL

DEVELOPMENT OF SEMICONDUCTOR LIGHT SOURCES WITH RUBY LASERS AND ZINC-DOPED GaAs JUNCTION DIODES  
REPT.-6400-42-T N66-12450

MEASUREMENT OF VERTICAL WATER VAPOR PROFILES BY MEANS OF THERMALLY TUNED RUBY LASER OPTICAL RADAR SYSTEM - HUMIDITY MEASUREMENT  
REPT.-65-6 N66-14852

LASER RESEARCH ACTIVITIES IN CHINESE PEOPLES REPUBLIC - FORMATION OF MICROWAVE MASER BY LASER PUMPING, AND FORMATION TIME OF GAS LASER OSCILLATIONS  
JPRS-33323 N66-15048

FORMATION OF MICROWAVE MASER BY PUMPING OF LOW TEMPERATURE RUBY LASER N66-15049

TIME RESOLVED INTERFEROMETRY, CINEMATOGRAPHY, AND TRAVELING WAVE CAVITY STUDIES ON RUBY LASERS  
AFCL-65-467 N66-16656

RUBY LASER RADIATION INTENSITY DISTRIBUTIONS BY HIGH SPEED CINEMATOGRAPHY AND TIME RESOLVED INTERFEROMETRY FOR PUMPED RADIATION EFFECTS  
N66-16657

SPECTRAL LINE WIDTH NARROWING IN TRAVELING WAVE RUBY LASER CAVITY EMISSION N66-16658

RUBY LASER PULSE TECHNIQUE APPLIED TO THERMAL DIFFUSIVITY MEASUREMENTS FOR TANTALUM AND GRAPHITE  
CONF-651020-1 N66-18228

RUBY LASER RADIATION SPECTRUM AND OPTICAL RESONANCE AT ROOM TEMPERATURE  
FTD-TT-65-1312/16264 N66-19914

RUBY GROWTH PROCESS FOR RANGEFINDER LASER RODS  
QPR-1 N66-19918

RUBY LASERS USED IN STUDYING PHYSICAL PROCESSES LEADING TO IONIZATION OF GASES BY INTENSE OPTICAL RADIATION  
UACRL-E920272-6 N66-20600

DYNAMIC STRESS CONCENTRATION USING PHOTOELASTICITY AND RUBY LASER LIGHT SOURCE  
T&AM-285 N66-20850

OPTICAL ABSORPTION AND ELECTRON PARAMAGNETIC RESONANCE TECHNIQUES USED TO STUDY IONIZING RADIATION EFFECT ON RUBY LASERS  
NASA-TN-D-3379 N66-21037

ELECTRON BEAM AND HOLLOW CATHODE FLOAT-ZONE PROCESSES ANALYSIS FOR APPLICATION TO GROWTH OF LASER RUBY CRYSTALS  
AFCL-65-908 N66-21169

FLASH PHOTOLYSIS APPARATUS FOR STUDYING SHORT LIVED CHEMICAL INTERMEDIATES FROM METHYLENE BLUE  
PSL-102 N66-21833

RUBY LASER HIGH SPEED PHOTOGRAPHY OF CAVITATION DAMAGE TO SOLIDS DUE TO HIGH SPEED JETS FROM COLLAPSING BUBBLES  
E-115.1 N66-21887

LASER BEAM TRACKING OF BEACON EXPLORER SATELLITES  
NASA-TM-X-56631 N66-22191

RUBY LASER TEMPERATURE-JUMP RELAXATION KINETIC STUDIES OF RAPID REACTIONS  
UUCD-2-64 N66-23078

DYNAMICS AND CHARACTERISTICS OF SELF-TRAPPING OF INTENSE LIGHT BEAMS  
NASA-CR-74030 N66-23765

RUTILE  
LINE WIDTHS AND INVERSION RATIOS OF IRON DOPED RUTILE FOR SUITABILITY IN BROADBAND MASERS  
A65-19622

CHROMIUM-DOPED RUTILE MASER INVERSION RATIO CROSS

RELAXATION EFFECT OPERATING AT LIQUID NITROGEN TEMPERATURES A65-23385

PUMP FREQUENCY OF 30 GIGACYCLES USING HARMONIC CROSS RELAXATION ON CHROMIUM DOPED RUTILE TO OBTAIN POPULATION INVERSION AT 40 GIGACYCLE SIGNAL FREQUENCY A65-25873

C-BAND TRAVELING WAVE MASER / TWM/ WITH IRON DOPED RUTILE CRYSTAL AND MEANDER LINE SLOW WAVE CIRCUIT A65-33373

LINE WIDTH AND INVERSION RATIOS OF IRON-DOPED RUTILE FOR OPTICAL MASER APPLICATIONS  
NASA-TM-X-54754 N65-29390

L-BAND TRAVELING-WAVE MASER FOR RADIO ASTRONOMY RESEARCH AT 21 CM USES CHROMIUM-DOPED RUTILE A66-16640

## S

SAFETY  
BIOLOGICAL EFFECTS OF LASER RADIATION AND SAFETY RULES FOR PERSONNEL PROTECTION  
NAVTRADEVEN-1H-15 N65-14941

SAMARIUM  
SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM FLUORIDE DOPED WITH SAMARIUM A65-24085

LASER ACTION AT LIQUID HELIUM TEMPERATURE IN CRYSTALS OF LEAD SAMARIUM, LEAD SELENIDE AND LEAD TELLURIDE EXCITED BY FAST ELECTRON BEAM A65-30346

SAPPHIRE  
ELECTRON BEAM AND HOLLOW CATHODE FLOAT-ZONE PROCESSES ANALYSIS FOR APPLICATION TO GROWTH OF LASER RUBY CRYSTALS  
AFCL-65-908 N66-21169

SATELLITE  
IMPROVEMENT OF FORECASTS AND ANALYSIS OF LASER MEASUREMENTS FOR SATELLITE S-66  
NASA-TT-F-8772 N66-11607

SATELLITE COMMUNICATION  
TRAVELING WAVE MASER FOR TELSTAR AND RELAY SATELLITES, DISCUSSING ELECTRONICS AND SOLID STATE PHYSICS PRINCIPLES AND DESIGN A65-16798

RADIO STATION FACILITIES AT RAISTING, WEST GERMANY NOTING SATELLITE COMMUNICATION, MASER RECEIVING SYSTEM, PARABOLIC ANTENNAS, ETC A65-35195

SATELLITE NAVIGATION SYSTEM  
SATELLITE-BORNE LASER ELECTRO-OPTICAL NAVIGATION SYSTEM, ANALYZING ANGULAR TRACKER AND CORNER-REFLECTOR SENSOR A65-29242

SATELLITE TRACKING  
LASER RANGING EXPERIMENTS PERFORMED WITH BEACON EXPLORER B A65-21303

OPTICAL TRACKING OF SATELLITES EQUIPPED FOR GEODETIC TRIANGULATION, USING GROUND LASER BEAMS A65-29936

ACCURATE TRACKING OF BEACON- EXPLORER ORBITING OPTICAL REFLECTORS, USING PULSED RUBY LASER BEAMS A66-19902

LASER BEAM TRACKING OF BEACON EXPLORER SATELLITES  
NASA-TM-X-56631 N66-22191

SCALE MODEL  
MICROWAVE MODELS OF OPTICAL RESONATORS - LASER OR MICROWAVE RESONATOR WITH FLAT ROOF MIRRORS - OPEN LASER RESONATORS RESEARCH  
AFCL-65-568 N65-34155

PULSED LASER OSCILLATOR - ADVANCED DEVELOPMENT MODEL  
ECCM-00326-4 N66-12398



## SCANNING DEVICE

LARGE-ANGLE NONMECHANICAL SCANNING OF LIGHT IN ONE AND TWO DIMENSIONS THROUGH OPTICAL REFRACTION BY TRAVELING ACOUSTIC WAVES A65-21326

LASER BEAM MODULATING TECHNIQUES AND SCANNING DEVICE TO FORM OPTIMAL VISUAL DISPLAYS N65-20562  
RADC-TDR-64-365

LARGE-ANGLE DEFLECTION METHOD FOR PRODUCTION OF TV TYPE RASTER SCAN IN LASER DISPLAY SYSTEM N66-22498  
U2-912008-2

## SCATTERING

OPTICAL MASER APPLIED TO BRILLOUIN SCATTERING SPECTROSCOPY N65-19528  
AROD-3922-13

PARAMETRIC EXCITATION OF ACOUSTIC WAVES IN SIMULATED BRILLOUIN SCATTERING N65-29906  
REPT.-1935-5

## SCATTERING CROSS SECTION

VARIATION OF SCATTERING CROSS SECTION WITH BEAM INTENSITY FOR RUBY LASER LIGHT ON ATOMIC HYDROGEN A66-15864

CROSS SECTION MEASUREMENT FOR ELECTROMAGNETIC BACKSCATTERING OF LASER BEAMS FROM ROUGH ALUMINUM AND MAGNESIUM OXIDE SURFACES A66-18930

LASER SCATTERING BY BOUND CHARGED PARTICLES A66-23080

## SCATTERING MATRIX

SINGLE RESONATOR REFLECTION AMPLIFIER ANALYSIS IN TERMS OF SCATTERING MATRIX DESCRIPTION OF OPTICAL RESONATOR A65-25885

## SCHLIEREN PHOTOGRAPHY

HE- NE GAS LASER APPLICATION TO SCHLIEREN PHOTOGRAPHY AND MACH- ZEHNDER INTERFEROMETRY IN AERODYNAMIC TESTING A65-22501

INTERFEROMETER USING SMALL DIFFRACTION GRATING AND GAS LASER LIGHT SOURCE IN SCHLIEREN SYSTEM FOR FLUID MECHANICS RESEARCH A65-25332

NEON-HELIUM GAS LASER APPLICATION TO SCHLIEREN PHOTOGRAPHY AND MACH- ZEHNDER INTERFEROMETRY FOR USE IN AERODYNAMIC TESTING N65-21372

ONSET OF RETONATION, LASER TECHNOLOGY AND HIGH REPETITION-HIGH RESOLUTION SCHLIEREN STROBOSCOPIC WAVE PHENOMENA RECORDS A66-19200

ADAPTABILITY OF LASERS TO SCHLIEREN SYSTEMS - PHOTOGRAPHIC LIGHTING SYSTEMS N66-14801  
ARL-65-139

## SCHRÖDINGER EQUATION

LASER SYSTEM COHERENCE PROPERTIES OF STATISTICAL OPERATOR R IN LIGHT FIELD, USING SCHRÖDINGER EQUATION ASSUMING GLAUBER STATE A65-25265

## SEA WATER

LIGHT SCATTERING IN SEA WATER - FORWARD SCATTERING OF LASER BEAM IN SEA WATER AND FORTRAN PROGRAM SCATTERING CALCULATIONS N65-23316  
AD-610126

## SEARCH RADAR

CLEAR AIR TURBULENCE DETECTION WITH LASER DOPPLER OPTICAL RADAR A66-24498  
AIAA PAPER 66-374

## SECONDARY EMISSION

RADIATION FLUCTUATIONS IN LASER PULSE REGIME, DISCUSSING ERRORS ARISING IN COMPARING BASIC WITH SECONDARY EMISSION A65-14617

## SECONDARY HARMONIC GENERATION

PARAMETRIC AMPLIFICATION IN ADENOSINE DIPHOSPHATE USING SECONDARY HARMONIC PRODUCED BY RUBY LASER N65-18629  
RADC-TDR-64-484

## SELENIUM

SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION,

CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION, FREQUENCY MODULATION LASERS, AND GALLIUM COMPOUND INGOTS FOR LASER APPLICATION N65-23135  
AFCL-64-1007

SILICON AND SELENIUM DOPING EFFECTS ON GALLIUM ARSENIDE LASER CHARACTERISTICS A66-21879

## SELF-CONSISTENT FIELD /SCF/

SELF-CONSISTENT FIELD ANALYSIS FOR FIELD DISTRIBUTIONS OF RESONANT MODES IN SPHERICAL MIRROR FABRY- PEROT RESONATOR A65-16566

MASTER EQUATION FOR COMPLETE STATISTICAL OPERATOR OF SOLID STATE LASER ACCORDING TO QUANTUM MECHANICS A65-31773

## SELF-EXCITATION

PARAMETER OF EXCITATION OF MOLECULAR BEAM TYPE MASER RESONATOR N65-27253

## SELF-SUSTAINED EMISSION

THRESHOLD CONDITIONS FOR CONTINUOUS SELF-SUSTAINED OSCILLATIONS PRODUCED BY REGENERATIVE RUBIDIUM GAS MASER A65-17659

SELF-SUSTAINED RUBIDIUM 87 MASER OSCILLATOR N66-10395

## SEMICONDUCTOR

SEMICONDUCTOR PULSE MASER BASED ON THEORY OF EXISTENCE OF ELECTRODIPOLE TRANSITIONS WITH SPIN ORIENTATION SHIFTS A65-20909

SUPERCONDUCTING STATES IN IMPURITY-FREE SEMICONDUCTORS CREATED BY LASER ILLUMINATION A65-28492

SECOND HARMONIC LIGHT GENERATION IN CADMIUM SULFIDE CRYSTAL NEAR ABSORPTION BAND A65-31220

HOMOGENEITY AND DIFFUSION LENGTH OF MINORITY CARRIERS IN SEMICONDUCTORS MEASURED, USING LASER BEAM A65-33809

DOUBLE PHOTON ABSORPTION, HARMONIC GENERATION, AND FREQUENCY MIXING IN SEMICONDUCTORS, AND FREQUENCY TUNING OF INJECTION LASERS BY UNIAXIAL STRESS N65-14437  
AD-450756

RESEARCH REPORTS ON CODER COMPONENTS, POLYMERS, SPECTROSCOPY, LASERS, ELECTROCHEMISTRY, TRANSMISSION LINES, AND SEMICONDUCTOR PHYSICS N65-15565  
NAVWEPS-8150

FEASIBILITY OF SEMICONDUCTOR LASER AMPLIFIER N65-15881  
RADC-TDR-64-384

SOLID STATE AND MASER TECHNIQUES - BREADBOARD EVALUATION, MEASUREMENTS OF LOW-TEMPERATURE SEMICONDUCTOR, AND SUPERCONDUCTING THIN FILM TUNNELING EFFECTS N65-16017  
RADC-TDR-64-480

MODULATION OF REFLECTIVITY OF SEMICONDUCTORS ILLUMINATED BY INTENSE LASER BEAMS N65-16566  
SSD-TDR-64-253

CHARACTERISTICS, AND LIMITATIONS OF LASERS FOR APPLICATION IN MILITARY AND SPACE SYSTEMS - CRYSTAL, GLASS, GAS, LIQUID, SEMICONDUCTOR, AND QUASI-LASERS N65-26625  
LMSG-704217

RESEARCH IN FERROMAGNETISM, POLYMER CHEMISTRY, LASERS, SEMICONDUCTORS, AND SOLID STATE SPECTROSCOPY N65-26765  
NAVWEPS-8226

ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASER, TUNABLE LASER, GEOMETRICAL OPTICS, SEMICONDUCTOR OSCILLATION, AND SOLID STATE PLASMA STUDIES FOR MICROWAVE TRANSMISSION N65-27969  
ML-1316

EPITAXIAL DEPOSITION OF GERMANIUM ON GALLIUM ARSENIDE BY HYDROGEN REDUCTION OF GERMANIUM

# SUBJECT INDEX

# SEMICONDUCTOR LASER

- TETRACHLORIDE - SEMICONDUCTOR AND LASER PRODUCTION  
SRRC-RR-65-52 N65-34688
- ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASERS, TUNABLE LASERS, ELECTRON-PROTON INTERACTIONS, SEMICONDUCTORS, GEOMETRIC OPTICS, AND SOLID STATE PLASMA STUDIES  
ML-1351 N65-34887
- SIGNAL VELOCITY OF MASERS, AND MICROWAVE PHONON ATTENUATION AND PULSED HEAT RADIATION IN SINGLE CRYSTAL SEMICONDUCTORS  
REPT.-8 N65-36734
- SUPERCONDUCTING STATES IN IMPURITY-FREE SEMICONDUCTORS CREATED BY LASER ILLUMINATION  
A66-12091
- PARALLEL GROOVES AS SURFACE DAMAGE IN SEMICONDUCTORS PRODUCED BY RUBY LASER AS DIFFRACTION EFFECT  
A66-13753
- GALLIUM ARSENIDE LASER DIODES WITH HIGH OUTPUT COHERENT BEAM FOR COMMUNICATIONS SYSTEMS  
ECOM-2629 N66-21293
- MICROWAVE RADIATION RESEARCH - ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASERS, SEMICONDUCTOR OSCILLATIONS, RAMAN SCATTERING, FERROMAGNETIC BULK INSTABILITIES, AND NONUNIFORM PLASMAS  
ML-1410 N66-22741
- SEMICONDUCTOR DEVICE  
SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION, CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION, FREQUENCY MODULATION LASERS, AND GALLIUM COMPOUND INGOTS FOR LASER APPLICATION  
AFCL-64-1007 N65-23135
- GENERATION OF LIGHT USING SEMICONDUCTOR QUANTUM GENERATORS - SOLID STATE LASERS  
FTD-TT-65-337/164 N65-32851
- PULSED IR LASER SIMULATING RADIATION-INDUCED TRANSIENT IONIZATIONS IN SEMICONDUCTOR DEVICES AND CIRCUITS  
A66-14853
- SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION PROPERTY CHANGES DUE TO PULSED RUBY LASER RADIATION  
A66-15354
- SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION PROPERTY CHANGES DUE TO PULSED RUBY LASER RADIATION  
A66-20895
- SPECTRAL ANALYSIS OF OUTPUT FROM SINGLE CRYSTAL SEMICONDUCTOR GENERATOR EXCITED BY ELECTRON BEAM - LASERS  
FTD-TT-65-555/162&4 N66-12624
- SOLID STATE PHYSICS, SEMICONDUCTOR DEVICES, LASER RESEARCH, AND MATERIALS  
ESD-TDR-65-71 N66-15609
- SEMICONDUCTOR LASER  
CIRCUITRY, MECHANICAL CONSTRUCTION AND PRELIMINARY PERFORMANCE OF GALLIUM ARSENIDE LASER TRANSMITTER OPERATED AT ROOM TEMPERATURE  
A65-15327
- INJECTION DIODE LASER FROM DEGENERATED GALLIUM ARSENIDE WITH NEODYMIUM DOPED LAYER EMITTING AT 8700 ANGSTROMS  
A65-15995
- IN SB LONGITUDINAL INJECTION-PLASMA LASER, NOTING PLASMA PINCH AND MODE STRUCTURE  
A65-17210
- OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER BY P-N TRANSITIONS TO INCREASE POWER AND DIRECTIVITY OF EMISSION  
A65-17319
- CURRENT DISTRIBUTION CONTROL IN GALLIUM ARSENIDE INJECTION LASER SHOWING EFFECTS ON OSCILLATION MODE AND THRESHOLD  
A65-17665
- FORWARD BIASED P-N JUNCTION ELECTROLUMINESCENCE THEORY AND APPLICATIONS TO DIODE LASERS  
A65-18872
- SEMICONDUCTOR LASER DIGITAL DEVICES FOR GENERAL PURPOSE LOGIC CIRCUITS BASED ON NONLINEAR INTERACTION OF INTENSE OPTICAL SIGNALS  
A65-19342
- SPECTROSCOPIC DATA ON ABSORPTION, SPONTANEOUS FLUORESCENCE AND STIMULATED EMISSION IN ACTINIDES, TRANSITION METAL AND SEMICONDUCTOR LASER MATERIAL  
A65-21168
- SINGLE MODE OUTSIDE DIFFERENTIAL QUANTUM EFFICIENCIES OF CIRCULAR AND RECTANGULAR LASER DIODES COMPARED  
A65-21321
- ELECTROLUMINESCENCE OF ZINC DIFFUSED DIODES IN FORWARD AND REVERSE BIAS; OBSERVING EMISSION SPECTRA AND LASING ACTION IN NEAR-EDGE LINE  
A65-21617
- SELF-INDUCED OSCILLATIONS IN OUTPUT OF FABRY-PEROT GALLIUM ARSENIDE INJECTION LASER  
A65-21624
- LASER FUTURE POSSIBILITIES AND APPLICATION CONSIDERING OPTICALLY PUMPED SOLIDS, SEMICONDUCTORS AND ANCILLARY EQUIPMENT  
A65-21954
- PHYSICAL CONDITIONS FOR OBTAINING LASER EFFECT IN P-N JUNCTION AND TECHNOLOGY IN CONSTRUCTING LASER DEVICES  
A65-23847
- SOLID STATE LASERS WITH EMPHASIS ON PUMPING MECHANISMS, SEMICONDUCTOR DEVICES AND IMPURITY-PATRIX SYSTEMS  
A65-24007
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM FLUORIDE DOPED WITH SAMARIUM  
A65-24085
- PERFORMANCE CHARACTERISTICS OF GALLIUM ARSENIDE AND MIXED-CRYSTAL INJECTION LASERS SURPASS ALL OTHER LASERS IN EFFICIENCY AND CW POWER OUTPUT  
A65-24130
- LASER TYPES AND THEIR APPLICATION IN RADAR, INSTRUMENTATION, NAVIGATION AND COMMUNICATIONS  
A65-24131
- INDIUM ARSENIDE DIODE SPONTANEOUS AND LASER ELECTROLUMINESCENCE IN MAGNETIC FIELDS  
A65-24961
- KINETIC EQUATION THEORY APPLIED TO STEADY STATE LASER RADIATION DUE TO BAND-BAND TRANSITION IN SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS  
A65-26694
- JUNCTION REGION HEATING OF FABRY-PEROT GA AS INJECTION LASER TREATED BY THREE TECHNIQUES  
A65-26819
- PB SE DIODE LASER FABRICATION, PROPERTIES AND EMISSION SPECTRUM WITH PEAK AT 8.5 MICRONS  
A65-27602
- QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION  
A65-28487
- LASER ACTION IN ALLOYED GALLIUM ARSENIDE JUNCTION DIODE SUBMERGED IN LIQUID NITROGEN  
A65-29198
- GALLIUM ARSENIDE LASER DIODES BEHAVIOR AT HIGH PULSE RADIATION LOADS  
A65-29356
- LASER CURRENT-MONITORING DEVICE, SMALL CURRENT TRANSFORMER FEEDS SOLID-STATE PULSE-CODING DEVICE WHICH MODULATES GALLIUM-ARSENIDE LASER  
A65-29885
- SILICON CONTROL RECTIFIER LONG PULSE DRIVER FOR INJECTION LASERS  
A65-30330
- REABSORPTION AS DOMINANT LOSS MECHANISM FOR BOTH INCOHERENT AND COHERENT RADIATION IN GALLIUM ARSENIDE LUMINESCENT DIODE  
A65-30347

- OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER BY P-N TRANSITIONS TO INCREASE POWER AND DIRECTIVITY OF EMISSION A65-30372
- REVIEW OF SEMICONDUCTOR LASER DEVELOPMENTS NOTING MAGNETIC EFFECTS, MATERIALS FOR IR COHERENT RADIATION, OPTICAL LASER, HOLOGRAPHY, ETC A65-30594
- KINETIC EQUATION THEORY APPLIED TO STEADY STATE LASER RADIATION DUE TO BAND-BAND TRANSITION IN SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS A65-32952
- TIME RESOLVED SPECTRA FOR PULSE OPERATED GALLIUM ARSENIDE LASER DIODES A65-33372
- OPTICAL GAIN AND LOSSES OF GA AS LASER OF EPITAXIAL AND DIFFUSED TYPE A65-33380
- INTENSITY FLUCTUATIONS MEASURED IN EMISSION FROM VARIOUS LASING AND NONLASING MODES OF CONTINUOUS WAVE GA AS LASER A65-34687
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM FLUORIDE DOPED WITH SAMARIUM A65-34906
- SEMICONDUCTOR LASER WITH ELECTRON BEAM AS EXCITATION SOURCE - EMISSION DATA FOR VARIOUS BEAM CURRENT DENSITIES N65-20391
- SPECTRAL AND TRANSIENT CHARACTERISTICS OF SOLID STATE AND SEMICONDUCTOR LASERS, AND NONLINEAR INTERACTION OF COHERENT LIGHTWAVES DUE TO RAMAN EFFECT S-702 N65-21558
- FOUR-LEVEL, GAS, LIQUID, SEMICONDUCTOR, AND RUBY LASERS RSIC-195 N65-24836
- SEMICONDUCTOR INJECTION LASERS AND LAMPS RAE-TR-65095 N65-36334
- GALLIUM ARSENIDE INJECTION LASER FOR PROLONGED OPERATION AT LIQUID NITROGEN TEMPERATURES A66-10369
- THERMAL LIMITATIONS ON CAPABILITIES OF GALLIUM ARSENIDE P-N JUNCTION LASERS A66-10895
- LASER-ACTION THRESHOLD IN ELECTRON-BEAM EXCITED GALLIUM ARSENIDE AND EFFECT OF TEMPERATURE AND DOPING A66-10971
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION LASER COOLED BY HELIUM GAS FLOW A66-11190
- GENERAL PROGRESS OF SEMICONDUCTOR JUNCTION AND RUBY LASERS, ESPECIALLY IN EXPERIMENTAL FIELD A66-11370
- QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION A66-12086
- LIGHT EMISSION IN FORWARD BIASED SEMICONDUCTOR P-N JUNCTION A66-12577
- MODE GUIDING AND GAIN IN JUNCTION LASER DUE TO DIELECTRIC SANDWICH CONFINING WAVE PROPAGATION A66-13952
- SEMICONDUCTOR LASER RADIATION BY DIRECT ZONE-TO-ZONE TRANSITIONS A66-14273
- GALLIUM ARSENIDE P-N JUNCTION LASER DIODE COVERING INJECTION CURRENT DISTRIBUTION, DENSITY AND EMISSION SPECTRA VARIATION A66-14659
- RISE OF JUNCTION TEMPERATURE DURING CONTINUOUS OPERATION OF GA AS INJECTION LASER A66-14771
- MULTIPLE INTERNAL-REFLECTION FOLDED-PATH RECTANGULAR LASER CONFIGURATION FOR OBTAINING LENGTH OF ACTIVE MEDIA BETWEEN FABRY-PEROT
- REFLECTORS A66-16652
- STIMULATED EMISSION IN INDIUM ARSENIDE SHOWS EXCITATION THRESHOLD LOW AND LIGHT EMISSION HIGHLY DIRECTIONAL A66-17026
- OSCILLATION MODE CONTROL IN P-N JUNCTION LASERS FOR CURRENT DENSITY REDUCTION FOR STIMULATED EMISSION A66-17329
- EXCITATION OF SEMICONDUCTOR LASERS BY BEAM OF FAST ELECTRONS, DISCUSSING WORK OF SHOCKLEY, POPOV, KELDYSH AND KROKHIN A66-17337
- LASER DEVELOPMENT, DISCUSSING BASIC THEORY, PUMPING METHODS AND LASER TYPES A66-18700
- GENERATION IN CADMIUM SULFIDE DURING TWO-PHOTON OPTICAL EXCITATION BY RUBY LASER WITH MODULATED Q-FACTOR A66-19620
- SEMICONDUCTOR LASERS, FM TECHNIQUES AND MULTIPLE-SCATTER PATHS USED TO OVERCOME MODULATION NOISE UNDER VARYING WEATHER CONDITIONS A66-19915
- WAVELENGTH CHANGE OF SPONTANEOUS AND STIMULATED EMISSION WITH UNIAXIAL PRESSURE UNDER CW OPERATION OF GA AS DIODE LASER AT 4 DEGREES K A66-19922
- SINGLE FILAMENT JUNCTION LASER EMITTING COHERENT LIGHT OF SIMPLER MODES, SHOWING THAT LASER HAS TWO PORTIONS, EACH WITH SELECTIVE DIFFUSED REGION A66-21357
- DIRECT-INDIRECT TRANSITION EFFECT ON HALL EFFECT IN GALLIUM ARSENIC PHOSPHIDE/ A66-21570
- EFFECTIVE MASS IN IN AS AND IN SB FROM LANDAU SHIFT OF PEAK EMISSION IN LASER DIODES A66-21579
- GALLIUM ARSENIDE LASER EXCITATION BY FAST ELECTRONS A66-22146
- FORCED EMISSION FROM ELECTRON-EXCITED CADMIUM SELENIDE A66-22174
- CURRENT-VOLTAGE CHARACTERISTICS OF CW X-BAND GA AS MICROWAVE GUNN GENERATOR A66-23029
- LASER CRYSTALS PREPARED ECONOMICALLY BY SPLITTING ALONG CLEAVAGE PLANES A66-23293
- ELECTRON BEAM PUMPED LASERS, DISCUSSING ENERGY DISSIPATION IN FAST ELECTRONS PASSING THROUGH CRYSTAL, LASER SEMICONDUCTOR CHARACTERISTICS, ETC A66-23433
- HOLE AND ELECTRON SMEARING AND P-TYPE ABSORPTION INFLUENCE ON THRESHOLD CURRENT A66-23478
- PARAMETER DEPENDENCE OF INTERMEDIATE FREQUENCY VOLTAGE INDICATED DURING ESTABLISHMENT OF OPTIMUM CONDITIONS FOR OPTICAL RECEIVERS AND MERIT OF SUBCARRIER MIXING A66-23960
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION LASER COOLED BY HELIUM GAS FLOW A66-24011
- EXCITATION OF AXIAL OSCILLATION MODES IN SEMICONDUCTOR LASERS ANALYZED, BASED ON RATE EQUATIONS FOR CHEMICAL POTENTIALS OF CARRIERS AND NUMBER OF PHOTONS A66-24455
- DEVELOPMENT OF SEMICONDUCTOR LIGHT SOURCES WITH RUBY LASERS AND ZINC-DOPED GA AS JUNCTION DIODES REPT.-6400-42-T N66-12450
- CONFERENCE ON PHYSICAL PROBLEMS OF QUANTUM ELECTRONICS - NONLINEAR OPTICAL PHENOMENA, SEMICONDUCTOR LASERS, GAS DISCHARGES IN GAS LASERS, AND GAS BREAKDOWN IN LASER BEAM JPRS-34262 N66-18135

- LIGHT EMISSION FROM GALLIUM ARSENIDE SEMICONDUCTOR  
P-N JUNCTION INJECTION LASER  
NOTS-TP-3655 N66-19703
- SELECTED FOREIGN SCIENTIFIC AND TECHNICAL  
LITERATURE ON POTENTIAL THEORY, SEMICONDUCTOR  
LASERS, COMPOSITE PROPELLANTS, AROMATIC,  
POLYESTERS, AND TECTONICS N66-21862
- ZINC DIFFUSION IN GALLIUM ARSENIDE-PHOSPHIDE  
LASERS AND EFFECTS ON SEMICONDUCTOR JUNCTIONS  
AFCL-66-18 N66-22611
- SEMICONDUCTOR INJECTION LASER FOR CONTINUOUS  
OPERATION AT ROOM TEMPERATURE IN VISIBLE  
WAVELENGTH RANGE  
NASA-CR-74018 N66-23746
- SENSOR**
- RING LASER ANGULAR ROTATION SENSOR DESIGNED FOR  
CENTRIFUGE OPERATION  
AB-1272-0028-1 N65-16131
- LOW FREQUENCY MAGNETIC FIELD SENSOR - PROTON  
MASER ANTENNA DESIGN CONSTRUCTION AND  
PERFORMANCE  
RADC-TR-64-567 N65-32211
- SEPARATION**
- SEPARATION AND FOCUSING OF ATOMIC BEAMS FOR ATOMIC  
HYDROGEN MASERS N65-26679
- SHOCK TUNNEL**
- SHOCK TUBE LASER PUMPING - FOUR COMBINATIONS  
OF LASER CRYSTAL AND PUMPING CONFIGURATION  
U-3104 N65-28154
- SHOCK WAVE**
- MAGNETIC FIELD PROBE IN ELECTROMAGNETICALLY DRIVEN  
SHOCK TUBE AND COHERENT LIGHT IN IONIZING SHOCK  
WAVE PLASMA DIAGNOSTICS A65-29569
- FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD  
OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK  
SHOCK WAVE IN LASER BEAM A66-10263
- FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD  
OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK  
SHOCK WAVE IN LASER BEAM A66-13308
- EVOLUTION OF LUMINOUS ZONE OF PLASMA GENERATED BY  
FOCUSING LASER BEAM IN AIR A66-15097
- TEXT ON HIGH SPEED OPTICAL PULSE TECHNOLOGY,  
LASERS AND MEASURING TECHNIQUES, EMPHASIZING  
CAPACITOR DISCHARGE APPLICATION A66-22063
- MACH-ZEHNDER LASER INTERFEROMETER AS DIAGNOSTIC  
TOOL IN SHOCK TUBE EXPERIMENTS A66-23352
- PREIONIZATION AND SHOCK WAVE IONIZATION, ALFVEN  
WAVES, LASERS, AND INTERFEROMETER DEVELOPMENT  
NP-15355 N66-13913
- SHOCK WAVE PROPAGATION**
- ONSET OF RETONATION, LASER TECHNOLOGY AND HIGH  
REPETITION-HIGH RESOLUTION SCHLIEREN STROBOSCOPIC  
WAVE PHENOMENA RECORDS A66-19200
- SHOT NOISE**
- ATOMIC RELAXATION AND FLUCTUATIONS OF LASER  
PHOTONS DETERMINED BY ADDING PROBABILITY  
AMPLITUDES A65-20744
- NOISE BEHAVIOR OF POTENTIAL MINIMUM OF TRAVELING  
WAVE TUBES AND REDUCTION FACTOR FOR SHOT NOISE  
DETERMINED, USING LASERS A65-26936
- SIGNAL DISTORTION**
- THERMAL OPTICAL DISTORTION MEASUREMENTS FOR  
NEODYMIUM DOPED GLASS LASER ROD  
MDE-6236 N66-22419
- SIGNAL FADING**
- STATISTICAL DISTRIBUTION OF ARRIVAL ANGLE, SPOT  
LOCATION, AMPLITUDE, ETC. OF LASER BEAM TRAVERSING  
TURBULENT ATMOSPHERE A65-24931
- SIGNAL MEASUREMENT**
- EXPERIMENTAL PROCEDURE TO MEASURE PROBABILITY  
DENSITY AMPLITUDE OF ELECTRIC COMPONENT OF LASER  
RADIATION FIELD A65-21070
- EXPERIMENTAL PROCEDURE TO MEASURE PROBABILITY  
DENSITY AMPLITUDE OF ELECTRIC COMPONENT OF LASER  
RADIATION FIELD A65-31235
- STUDY OF PARAMETERS OF HIGH GAIN 2.026 MICRON  
XENON-HELIUM LASER TO OPTIMIZE POWER OUTPUT  
AND EFFECT OF TUBE DIAMETER ON SMALL SIGNAL GAIN  
WRE-PAD-104 N65-28901
- MEASURING DEVICE FOR PULSED LASER OUTPUT POWER  
USING BOLOMETER, AMPLIFIER AND OSCILLOSCOPE  
A66-13888
- SIGNAL MIXING**
- PARAMETER DEPENDENCE OF INTERMEDIATE FREQUENCY  
VOLTAGE INDICATED DURING ESTABLISHMENT OF OPTIMUM  
CONDITIONS FOR OPTICAL RECEIVERS AND MERIT OF  
SUBCARRIER MIXING A66-23960
- SIGNAL NOISE**
- NOISE IN GAS LASERS AND LASER DETECTORS,  
AMPLIFIERS AND OSCILLATORS, NOTING HELIUM-NEON  
LASER OSCILLATION A65-31002
- NOISE OUTPUT AND NOISE FACTOR OF OVERLOADED MASER  
AMPLIFIERS STUDIED AS FUNCTION OF SMALL-SIGNAL  
GAIN VS ACTUAL GAIN A65-31032
- SIGNAL PROCESSING**
- LASER LIGHT REDISTRIBUTION IN ILLUMINATING OPTICAL  
SIGNAL PROCESSING SYSTEMS NOTING APODIZATION,  
SPATIAL MODES AND ASPHERIC ELEMENTS A66-14830
- SIGNAL TO NOISE RATIO**
- MICROWAVE AMPLIFICATION ACHIEVED IN SILICON DIODE  
EXHIBITING MICROPLASMA-FREE AVALANCHE  
MULTIPLICATION A65-19227
- LASER BEACON FOR DAYLIGHT OPTICAL TRACKING -  
COMPONENTS DESCRIPTION, SIGNAL TO NOISE RATIO,  
AND SIGNAL SENSITIVITY  
NASA-CR-62616 N65-23285
- LASER COMMUNICATIONS LINK SECURITY AGAINST  
INTERCEPTION, EXAMINING FREQUENCY BANDWIDTH FOR  
MINIMUM SNR A66-16650
- COHERENT INTERFERENCE REJECTION, DISCUSSING NOISE  
AND MODULATOR-LEAKAGE PICKUP REJECTION IN LASER  
COMMUNICATIONS EXPERIMENTS A66-17217
- SIGNAL TRANSMISSION**
- SATELLITE REFLECTOR DESIGN FOR LASER BEAM  
RETROREFLECTION AND SATELLITE SIGNAL  
TRANSMISSION CALCULATIONS  
NASA-TN-X-55129 N65-18254
- SEARCH VIA LASER RECEIVERS FOR INTERSTELLAR  
COMMUNICATIONS A66-16669
- OSCILLATION, MODULATION AND TRANSMISSION PROBLEMS  
REGARDING LONG DISTANCE ELECTRIC SIGNAL  
COMMUNICATION POSSIBILITIES OF LASERS A66-18359
- TEXT ON HIGH SPEED OPTICAL PULSE TECHNOLOGY,  
LASERS AND MEASURING TECHNIQUES, EMPHASIZING  
CAPACITOR DISCHARGE APPLICATION A66-22063
- SILICA GLASS**
- GLASS COMPOSITION EFFECT ON SPECTRAL PROPERTIES OF  
ND-DOPED GLASSES AND SELECTING ONE FOR LASER  
GLASS A65-17635
- STIMULATED EMISSION IN SILICATE GLASS LASER  
CONTAINING NEODYMIUM A65-24189
- FRACTURES IN NEODYMIUM-DOPED ALKALINE SILICATES  
AND BOROSILICATES PRODUCED BY LASER BEAM A66-14174

## SILICIDE

PROPAGATION OF ATMOSPHERICS, RADIATIVE RECOMBINATION IN LASERS, RADIATION BELT SURROUNDING EARTH, EQUATION FOR LAMINAR BOUNDARY LAYER PROBLEMS, AND RARE EARTH SILICIDES  
N66-12644

## SILICON

FIRST ORDER RAMAN SCATTERING MEASUREMENT IN SILICON USING 6328-ANGSTROM OUTPUT OF HELIUM-NEON LASER  
A65-26457

PHONON INTERACTION IN CRYSTALS - TRANSIENTLY OPERATED ACOUSTIC MASER, INTERACTION OF PHONONS WITH IMPURITIES IN GERMANIUM AND SILICON, AND HEAT PULSES IN CRYSTALS  
QTR-7  
N65-27746

SILICON AND SELENIUM DOPING EFFECTS ON GALLIUM ARSENIDE LASER CHARACTERISTICS  
A66-21879

## SILICON CARBIDE

SEMICONDUCTOR INJECTION LASER FOR CONTINUOUS OPERATION AT ROOM TEMPERATURE IN VISIBLE WAVELENGTH RANGE  
NASA-CR-74018  
N66-23746

## SILICON CONTROL RECTIFIER /SCR/

SILICON CONTROL RECTIFIER LONG PULSE DRIVER FOR INJECTION LASERS  
A65-30330

## SILICON TETRACHLORIDE

LASER OSCILLATIONS OF SILICON TETRACHLORIDE, SILICON TETRAFLUORIDE AND ETHYL SILICATE IN GASEOUS DISCHARGE  
A66-14973

## SIMULATION

METEOROID SIMULATION USING LASERS  
NASA-TM-X-53122  
N65-17872

MICROWAVE ANTENNA SIMULATION AT OPTICAL FREQUENCY, USING NEON-HELIUM CONTINUOUS GAS LASER  
A66-22539

## SIMULATOR

PULSED LASER FOR SIMULATING TANK GUN FIRING FOR TRAINING OF TANK GUNNERS  
NAVTRADEVEN-1311-1  
N65-34674

## SINGLE CRYSTAL

INDUCED RADIATION AND LASER ACTION OF GALLIUM ARSENIDE SINGLE CRYSTAL EXCITED BY LIGHT FROM Q-MODULATED RUBY LASER  
A65-36362

GROWTH OF BROAD LINEWIDTH RUBY SINGLE CRYSTALS FROM FLUX AND ADDITION OF GALLIUM FOR HIGH OPTICAL LASERS  
R-11-454  
N65-28525

GROWTH OF HIGH OPTICAL QUALITY LANTHANUM-ALUMINUM OXIDE SINGLE CRYSTAL BY CZOCHRALSKI METHOD - DEFENDER PROJECT  
SRCR-65-4  
N65-34084

SIGNAL VELOCITY OF MASERS, AND MICROWAVE PHONON ATTENUATION AND PULSED HEAT RADIATION IN SINGLE CRYSTAL SEMICONDUCTORS  
REPT.-8  
N65-36734

PREPARATION OF SINGLE CRYSTALS OF DOUBLE MOLYBDATES OF NA AND LA /OR OTHER RARE EARTH ELEMENTS/ DOPED WITH ND, TB OR PR FOR LASER APPLICATION  
A66-13478

SPECTRAL ANALYSIS OF OUTPUT FROM SINGLE CRYSTAL SEMICONDUCTOR GENERATOR EXCITED BY ELECTRON BEAM - LASERS  
FTD-TT-65-555/16264  
N66-12624

GROWTH OF CUBIC PEROVSKITE CRYSTALS AS SYMMETRIC HOSTS FOR LASER DOPANT IONS  
SRCR-65-9  
N66-16824

VAPOR PHASE GROWTH OF RUBY SINGLE CRYSTALS FOR LASER APPLICATIONS  
AD-629154  
N66-23875

## SODIUM VAPOR

SODIUM-MERCURY METAL VAPOR LASER

SP/PH/65-15

N65-33995

## SOLAR ACTIVITY

COMBUSTION INSTABILITY, BALL LIGHTNING, SOLAR ACTIVITY, NOCTILUCENT CLOUDS, INTERSTELLAR COMMUNICATIONS, NEODYMIUM LASER, AND HYDROFOILS  
N65-34075

## SOLAR COLLECTOR

CYSPROSIUM DOPED CALCIUM FLUORIDE DOPED LASER, USING SOLAR RADIATION FOR EXCITATION AND OPERATING AT 77 DEGREES K  
A65-36361

## SOLAR FLARE

FOREIGN SCIENCE BULLETIN - GIANT RADIO TELESCOPE RAMAN SCATTERING LASERS - FORECASTING SOLAR FLARES - MAN-IN-SPACE - EPITAXIAL GROWTH OF ALUMINUM NITRIDE THIN FILMS - TECHNOLOGY  
N65-30979

GIANT RADIO TELESCOPE TO DETECT EXTRATERRESTRIAL RADIATION, RAMAN SCATTERING LASERS, FORECASTING SOLAR FLARES FOR MANNED SPACE FLIGHT, VOSKHOD II LIFE SUPPORT, AND ALUMINUM NITRIDE FILMS  
N65-32675

## SOLAR FLUX

RESEARCH IN CHINESE PEOPLES REPUBLIC - SOLAR FLUX, GAS DISCHARGE TUBE, NEODYMIUM LASER, GEOLOGICAL MECHANICS, MICROCRYSTALLINE GLASS, LOCATING OF THUNDER, AND PURIFICATION WITH DISTILLATION METHODS  
JPRS-33759  
N66-16806

## SOLAR POWER SOURCE

SUN-POWERED LASER TRANSMITTER DEVELOPMENT - RUBY, NEODYMIUM-DOPED GLASS, AND NEODYMIUM-DOPED CALCIUM TUNGSTATE LASER MATERIALS  
IER-1  
N65-29901

## SOLAR RADIATION

LECTURE MANUSCRIPTS ON HIGH ALTITUDE EXPLOSIONS, BIOLOGICAL EXPLORATION OF MARS, MASERS AND LASERS, PLANETARY ATMOSPHERES, RELATIVITY THEORY, ELEMENT ABUNDANCE, AND SOLAR PARTICLES  
N65-31360

LASER RADAR AS INSTRUMENT TO OBTAIN OPERATIONAL METEOROLOGICAL INFORMATION  
A66-21067

## SOLID STATE

GAS LASER OSCILLATOR AND SOLID STATE CHELATE LASER  
RADC-TDR-64-442  
N65-16013

SOLID STATE AND MASER TECHNIQUES - BREADBOARD EVALUATION, MEASUREMENTS OF LOW-TEMPERATURE SEMICONDUCTOR, AND SUPERCONDUCTING THIN FILM TUNNELING EFFECTS  
RADC-TDR-64-480  
N65-16017

SOLID STATE LASER AMPLIFIER STRUCTURES  
QPR-8  
N66-12048

## SOLID STATE DEVICE

SOLID STATE MICROWAVE MASER ACTION AT 77.4 DEGREES K WITH BROADBANDING TECHNIQUE APPLIED TO INCREASE GAIN-BANDWIDTH PRODUCT, EXAMINING RUBY MATERIAL AND HIGH Q MICROWAVE CAVITIES  
A65-23155

DEVICES OBTAINING INFORMATION FROM MODULATED LASER BEAMS INCLUDING PHOTOEMISSIVE DETECTORS AND SOLID STATE PHOTODETECTORS  
A65-23964

NINETEENTH ANNUAL CONVENTION OF ARMED FORCES COMMUNICATIONS AND ELECTRONICS ASSOCIATION ON LASER TECHNOLOGY AND APPLICATION AT FORT MONMOUTH, NEW JERSEY IN JUNE 1965  
A65-31879

LASER CONFIGURATIONS, PERFORMANCE FEATURES AND LIMITATIONS DISCUSSING HE- NE, ION AND SOLID STATE LASERS  
A65-31881

SOLID STATE DEVICE, LASER, MATERIALS, BAND STRUCTURE AND SPECTROSCOPY OF SOLIDS, AND MAGNETISM AND RESONANCE RESEARCH  
ESD-TDR-64-560  
N65-16944

SOLID STATE LASER AND PHASE SHIFTER DESIGN FOR

# SUBJECT INDEX

# SOLID STATE LASER

- COHERENT OPTICAL RADAR  
AB-1272-0016-2 N65-17148
- LASER, MATERIALS, AND SOLID STATE RESEARCH, BAND  
STRUCTURE AND SOLIDS SPECTROGRAPHY, AND  
MAGNETISM AND RESONANCE  
ESD-TDR-64-349 N65-19816
- SOLID STATE RESEARCH REPORT INCLUDING SOLID STATE  
DEVICES, LASERS, MATERIALS, BAND STRUCTURE,  
MAGNETISM AND RESONANCE, AND SPECTROSCOPY OF  
SOLIDS  
ESD-TDR-65-31 N65-25537
- SOLID-STATE AND TRAVELING-WAVE MASER TECHNIQUES  
RADC-TR-65-30 N65-33397
- THEORETICAL EXPLANATION FOR HIGHLY DIRECTIONAL  
OFF AXIAL RADIATION FROM SOLID STATE OPTICAL  
MASERS OF CIRCULAR CROSS SECTION  
TR-2 N65-34713
- LASER DIGITAL DEVICES, EXAMINING QUENCHING OF GAIN  
AND OPTICAL ABSORPTION A66-14826
- GAIN BANDWIDTH AND STABILITY OF SOLID STATE  
MULTICAVITY MASERS A66-22765
- SOLID STATE DEVICES, LASERS, AND MATERIALS SCIENCE  
ABSTRACTS - ANNOTATED BIBLIOGRAPHY  
ESD-TDR-65-318 N66-16745
- SOLID STATE LASER**
- HIGH SYMMETRY OSCILLATIONS IN CONTINUOUS WATER  
COOLED SOLID STATE LASERS, SHOWING RELATION TO  
EXCITATION CONDITIONS A65-14185
- CRYSTAL GROWTH AND PREPARATION OF POTENTIAL LASER  
MATERIAL CONTAINING RARE EARTH IONS AS DOPANTS  
A65-17042
- NEODYMIUM DOPED CALCIUM TUNGSTATE ROOM TEMPERATURE  
AMPLIFIER AND CW-LASER OSCILLATOR A65-18873
- PHENOMENOLOGICAL TREATMENT OF SATURATION EFFECTS  
IN SOLID STATE LASER AMPLIFIERS A65-18887
- LASER ACTION THEORY IN CRYSTALLINE OPTICAL SOLID,  
DISCUSSING PROMISING MATERIALS AND MULTIPHONON  
PROCESSES IMPORTANCE IN LINE WIDTH AND TRANSITION  
PROBABILITIES A65-19997
- OSCILLATORY BEHAVIOR OF NEODYMIUM DOPED CALCIUM  
TUNGSTATE SOLID STATE LASERS WITH CW EMISSION  
BASED ON RATE EQUATIONS A65-19998
- SEMICONDUCTOR PULSE MASER BASED ON THEORY OF  
EXISTENCE OF ELECTRODIPOLE TRANSITIONS WITH SPIN  
ORIENTATION SHIFTS A65-20909
- SOLID STATE LASERS WITH EMPHASIS ON PUMPING  
MECHANISMS, SEMICONDUCTOR DEVICES AND IMPURITY-  
MATRIX SYSTEMS A65-24007
- AUTOMODULATION OF EMISSION FROM SOLID STATE LASER  
A65-24809
- MIRROR HOLDER WITH DEFORMABLE HINGES GIVING  
CONSTANT HINGE LINES AT RIGHT ANGLES FOR GASEOUS  
AND SOLID STATE LASERS USE A65-28590
- RELAXATION OSCILLATIONS IN FOUR-LEVEL SOLID STATE  
LASER STUDIED VIA DIFFERENTIAL EQUATIONS,  
CALCULATING SHAPE AND ENVELOPE OF OSCILLATION  
A65-30574
- Q-SWITCHING APPLIED TO SLOW SWITCHING AND PULSE  
SHAPING FOR SOLID STATE LASERS  
AIAA PAPER 65-343 A65-30797
- TEMPERATURE RISE AT GA AS LASER JUNCTION FOR  
VARIOUS PULSE CURRENTS AND BASE TEMPERATURES  
A65-31732
- MASTER EQUATION FOR COMPLETE STATISTICAL OPERATOR  
OF SOLID STATE LASER ACCORDING TO QUANTUM  
MECHANICS A65-31773
- ELECTRON PARAMAGNETIC RESONANCE THEORETICAL  
ASPECTS AND APPLICATION TO ATOMIC NUCLEI  
POLARIZATION, INCREASED SPECTROMETER RESOLUTION  
AND SOLID STATE MASERS A65-32773
- SYNCHRONIZED GENERATION OF RADIATION BY ALL  
SEMICONDUCTOR ELEMENTS OF LASER SYSTEM WITH  
RADIATIVE MIRRORS CAUSED BY DIFFRACTION OF  
ELECTROMAGNETIC FIELD A65-35279
- GALLIUM ARSENIDE LUMINESCENT DIODES WITH  
TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION  
AT HIGH DENSITY CURRENT A65-36787
- ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION  
IN NEODYMIUM GLASS LASER A65-36826
- GAIN COEFFICIENTS AND MEASUREMENTS IN LASER  
AMPLIFIER, AND SOLID STATE LASER MATERIALS  
CR-6 N65-14465
- SOLID STATE DEVICE, LASER, MATERIALS, BAND  
STRUCTURE AND SPECTROSCOPY OF SOLIDS, AND  
MAGNETISM AND RESONANCE RESEARCH  
ESD-TDR-64-560 N65-16944
- SOLID STATE LASER AND PHASE SHIFTER DESIGN FOR  
COHERENT OPTICAL RADAR  
AB-1272-0016-2 N65-17148
- LASER, MATERIALS, AND SOLID STATE RESEARCH, BAND  
STRUCTURE AND SOLIDS SPECTROGRAPHY, AND  
MAGNETISM AND RESONANCE  
ESD-TDR-64-349 N65-19816
- SPECTRAL AND TRANSIENT CHARACTERISTICS OF SOLID  
STATE AND SEMICONDUCTOR LASERS, AND NONLINEAR  
INTERACTION OF COHERENT LIGHTWAVES DUE TO RAMAN  
EFFECT  
S-702 N65-21558
- PLANAR, CONFOCAL, AND SOLID STATE LASERS  
N65-25126
- SOLID STATE RESEARCH REPORT INCLUDING SOLID STATE  
DEVICES, LASERS, MATERIALS, BAND STRUCTURE,  
MAGNETISM AND RESONANCE, AND SPECTROSCOPY OF  
SOLIDS  
ESD-TDR-65-31 N65-25537
- COMPACT SOLID STATE CESIUM LASER BEAM FREQUENCY  
STANDARD FOR PRECISION CLOCKS N65-26681
- STATISTICAL CHARACTERISTICS OF AUTOMODULATION OF  
SOLID LASER RADIATION N65-27234
- GENERATION OF LIGHT USING SEMICONDUCTOR QUANTUM  
GENERATORS - SOLID STATE LASERS  
FTD-TT-65-337/164 N65-32851
- SOLID STATE LASERS, ACOUSTICS, AND REGENERATION OF  
MUSCLE TISSUE - TRANSLATIONS OF CHINESE  
PEOPLES REPUBLIC ARTICLES ON SCIENCE AND  
TECHNOLOGY  
JPRS-31817 N65-36115
- SOLID STATE LASERS - PROBLEMS OF CONTINUOUS  
STIMULATED EMISSION IN SOLIDS, MATERIALS, LIGHT  
SOURCES, COOLING, AND APPLICATIONS  
N65-36116
- SEMICONDUCTOR-BASED PULSE GENERATOR FOR LASER  
EXCITATION A66-11042
- TWO- AND THREE-STEP LASER CASCADES DETECTED  
EXPERIMENTALLY IN HELIUM-NEON MIXTURES, ANALYZING  
TWO-STEP CASCADE STARTING WITH DENSITY MATRIX  
FORMULATION A66-11477
- HIGH POWER RELAXATION OSCILLATION IN MULTILEVEL  
SOLID STATE RUBY MASER DUE TO MAGNETIC FIELD  
MODULATION A66-13327
- ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION  
IN NEODYMIUM GLASS LASER A66-13431
- APPLICATION, PROBLEMS AND STATE OF LOW NOISE  
AMPLIFIERS AND TRAVELING WAVE TUBES, MASER AND  
ADLER TUBES GAIN IN RADAR SYSTEMS

- A66-14123  
REGULAR PERIODIC SPIKING IN OUTPUT OF PULSED  
NEODYMIUM DOPED BORATE GLASS LASER AT PUMPING  
LEVELS SLIGHTLY ABOVE THRESHOLD
- A66-16672  
DERIVATION OF TWO EQUATIONS FOR ELECTROMAGNETIC  
FIELD AND POPULATION INVERSION IN SOLID STATE  
LASER
- A66-16773  
SOLID STATE LASER SYSTEM, DESCRIBING QUANTUM  
MECHANICAL TREATMENT OF SELF-SUSTAINED OSCILLATION  
FOR ONE MODE
- A66-17817  
APPARATUS FOR FLUORIDATION OF HYDROXYL AND OXYGEN  
CONTAMINATED FLUORIDE COMPOUNDS, OBTAINING  
OPTICALLY CLEAR CRYSTALS WITH NO TYNDALL  
SCATTERING FOR LASER APPLICATION
- A66-18488  
GALLIUM ARSENIDE LUMINESCENT DIODES WITH  
TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION  
AT HIGH DENSITY CURRENT
- A66-19195  
SOLID STATE LASER OUTPUT EXHIBITING REGULAR AND  
IRREGULAR SPIKES ANALYZED THROUGH RELAXATION  
OSCILLATIONS AND CLASSICAL PHYSICS
- A66-20568  
SEMICONDUCTOR-BASED PULSE GENERATOR FOR LASER  
EXCITATION
- A66-23289  
MODULATING OUTPUT OF SOLID-STATE LASERS  
D-920259-12
- N66-12814  
MATERIAL TESTING FOR GAS LASER OSCILLATOR AND  
SOLID STATE CHELATE LASER - OPTICAL RADARS  
RADG-TR-64-526
- N66-12838  
SOLID STATE OPTICAL MASER RESEARCH - YTTRIUM-  
ALUMINUM-GARNET NEODYMIUM LASER OSCILLATOR AS  
REGENERATIVE NOISE AMPLIFIER - AMPLITUDE  
FLUCTUATIONS
- N66-14272  
PULSED YTTRIUM-ALUMINUM GARNET NEODYMIUM LASER  
DEVICE - SOLID STATE LASER DEVICE
- N66-14725  
GALLIUM ARSENIDE LASER DIODES WITH HIGH OUTPUT  
COHERENT BEAM FOR COMMUNICATIONS SYSTEMS  
ECOM-2629
- N66-21293  
**SOLID STATE PHYSICS**  
SOLID STATE PHYSICS - LASERS, SPECTROSCOPY OF  
SOLIDS, MAGNETISM, AND RESONANCE  
ESD-TDR-64-561
- N65-19317  
PHYSICAL ELECTRONICS, SOLID STATE PHYSICS, LIQUID  
STATE PHYSICS, INFORMATION SCIENCES, AND LASER  
AND COMMUNICATION THEORY  
LMSC-6-75-65-10
- N65-25125  
ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASERS,  
TUNABLE LASERS, ELECTRON-PROTON INTERACTIONS,  
SEMICONDUCTORS, GEOMETRIC OPTICS, AND SOLID  
STATE PLASMA STUDIES  
ML-1351
- N65-34887  
OPTICAL MASER AS POWER SOURCE FOR NARROW BAND  
ELECTROMAGNETIC RADIATION THROUGH STIMULATED  
RAMAN SCATTERING - SOLID STATE PHYSICS  
REPT.-1935-6
- N66-10581  
SOLID STATE PHYSICS, SEMICONDUCTOR DEVICES, LASER  
RESEARCH, AND MATERIALS  
ESD-TDR-65-71
- N66-15609  
INVESTIGATIONS IN ASTRONOMY, SOLID STATE PHYSICS,  
OPTICAL MASERS, ATOMIC PHYSICS, AND RADIOACTIVE  
ATOMS FOR ELECTROMAGNETIC APPLICATIONS  
NASA-CR-70391
- N66-17320  
**SOUND VELOCITY**  
STIMULATED BRILLOUIN AND RAMAN SCATTERING IN  
GASES, DISCUSSING SOUND VELOCITY CALCULATION FROM  
FREQUENCY SHIFT AND ARGON, HYDROGEN AND NITROGEN  
A66-13981
- SOUND WAVE**  
BRILLOUIN SCATTERING IN LIQUIDS EXAMINING  
VELOCITY, FREQUENCY AND LIFETIME OF THERMALLY  
EXCITED HYPERSONIC SOUND WAVES, USING LASER LIGHT  
SOURCES
- A66-12422  
MICROWAVE RADIATION RESEARCH - ACOUSTIC WAVE  
AMPLIFICATION, OPTICAL MASERS, SEMICONDUCTOR  
OSCILLATIONS, RAMAN SCATTERING, FERROMAGNETIC  
BULK INSTABILITIES, AND NONUNIFORM PLASMAS  
ML-1410
- N66-22741  
**SPACE COMMUNICATION**  
OPTICAL COMMUNICATION IN SPACE USING LASERS,  
EMPHASIZING NATURAL LIMITATIONS, E.G., ATMOSPHERIC  
ABSORPTION
- A65-21077  
IMPROVEMENTS NEEDED IN LASER TECHNOLOGY BEFORE  
OPTICAL COMMUNICATION CAN REPLACE UHF BECAUSE OF  
LIMITED RELIABILITY OF MICROBEAM OPTICAL LINK
- A65-23196  
SYSTEMS ANALYSIS OF LASERS VS MICROWAVES FOR  
MARS-TO- EARTH COMMUNICATIONS IN 1970
- A65-28248  
ACQUISITION, TRACKING AND BEAM POINTING FOR  
OPTICAL COMMUNICATION IN SPACE  
AIAA PAPER 64-420
- A65-33536  
MEASUREMENTS AND LIMITATIONS OF ATMOSPHERIC  
EFFECTS ON LASER PROPAGATION FOR SPACE  
COMMUNICATION  
NASA-CR-67382
- N65-35846  
SPACE-TO-SPACE AND EARTH-TO-SPACE COMMUNICATION  
SYSTEMS USING LASER SOURCES  
RADG-TCR-64-289
- N66-22582  
**SPACE EXPLORATION**  
NASA PROGRAM OF ADVANCED SPACE RESEARCH AND  
TECHNOLOGY - PLANETARY EXPLORATION, ENERGY  
CONVERSION, MATERIALS SCIENCE, AND LASERS
- N66-12404  
**SPACE RADIATION**  
GIANT RADIO TELESCOPE TO DETECT EXTRATERRESTRIAL  
RADIATION, RAMAN SCATTERING LASERS, FORECASTING  
SOLAR FLARES FOR MANNED SPACE FLIGHT, VOSKHOD  
II LIFE SUPPORT, AND ALUMINUM NITRIDE FILMS
- N65-32675  
**SPACE SURVEILLANCE SYSTEM**  
HIGH POWER LASER AMPLIFIER FOR OPTICAL RADAR  
TRANSMITTER - SPACE SURVEILLANCE SYSTEM  
EOS-5550-Q-1
- N66-12355  
**SPACE SYSTEMS ENGINEERING**  
CHARACTERISTICS, AND LIMITATIONS OF LASERS FOR  
APPLICATION IN MILITARY AND SPACE SYSTEMS -  
CRYSTAL, GLASS, GAS, LIQUID, SEMICONDUCTOR, AND  
QUASI-LASERS  
LMSC-704217
- N65-26625  
**SPACECRAFT COMMUNICATION**  
LASER BEAM COMMUNICATION BETWEEN DEEP-SPACE  
VEHICLE AND EARTH TRACKING STATION - CLOSED LOOP  
SYSTEM AND LEAD ANGLE COMPUTATIONS FOR TARGET  
MOTION COMPENSATION  
NASA-CR-60699
- N65-16811  
SPACE-TO-SPACE AND EARTH-TO-SPACE COMMUNICATION  
SYSTEMS USING LASER SOURCES  
RADG-TDR-64-289
- N66-22582  
**SPACECRAFT COMMUNICATIONS SYSTEM**  
ACQUISITION AND REACQUISITION IN SPACECRAFT-  
SPACECRAFT AND SPACECRAFT-TO- EARTH COMMUNICATIONS  
USING LASER SYSTEMS
- A65-28249  
SPACE COMMUNICATION REQUIREMENTS USING LASERS AND  
MICROWAVES IN MANNED MARS FLIGHTS  
ATAA PAPER 65-324
- A65-30519  
**SPACECRAFT GUIDANCE**  
ACCURATE LOCATION OF OBJECT IN SPACE AND TIME AND  
CORRECTION OF MOVEMENTS BY USE OF QUANTUM  
ELECTRODYNAMICS
- A65-25036

# SUBJECT INDEX

# SPECTRAL LINE WIDTH

## SPALLING

LIFE SUPPORT SYSTEM, FLUID AMPLIFICATION,  
SPALLING, COMMUNICATIONS SATELLITE, MICROWAVE  
APPARATUS, HIGH STRENGTH STEEL, TRACERS, LASERS,  
ATMOSPHERIC TURBULENCE, AND RESONANCE  
AD-611432 N65-22732

## SPARK DISCHARGE

SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-14131

SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-24951

SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER  
RADIATION, DETERMINING TEMPERATURE OF PLASMA  
PRODUCED NEAR FOCUS A65-31705

SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER  
RADIATION, DETERMINING TEMPERATURE OF PLASMA  
PRODUCED NEAR FOCUS A66-19959

TEXT ON HIGH SPEED OPTICAL PULSE TECHNOLOGY,  
LASERS AND MEASURING TECHNIQUES, EMPHASIZING  
CAPACITOR DISCHARGE APPLICATION A66-22063

## SPARK GAP

LASERS AS TRIGGERING MECHANISM FOR SPARK GAPS,  
NOTING DELAY TIME BETWEEN PULSE ARRIVAL AND  
CURRENT FLOW A66-13247

## SPATIAL DISTRIBUTION

SPATIAL DISTRIBUTION OF ELECTRICAL FIELD OBTAINED  
BY FOCUSING RADIATION OF RUBY LASER A66-10250

SPATIAL DISTRIBUTION OF HOLLOW-CONE SHAPED  
EMISSION OF MODES WHICH ARE TOTALLY REFLECTED IN  
NEODYMIUM-GLASS LASERS A66-14291

## SPATIAL FILTERING

LASER DEFLECTION AND SCANNING BY MEANS OF  
MULTIMODE CAVITIES WITH DYNAMIC SPATIAL FILTERS  
A66-14829

LASER LIGHT REDISTRIBUTION IN ILLUMINATING OPTICAL  
SIGNAL PROCESSING SYSTEMS NOTING APODIZATION,  
SPATIAL MODES AND ASPHERIC ELEMENTS A66-14830

## SPECTRAL ANALYSIS

GLASS COMPOSITION EFFECT ON SPECTRAL PROPERTIES OF  
ND-DOPED GLASSES AND SELECTING ONE FOR LASER  
GLASS A65-17635

OPTICAL ANALOG COMPUTER TRANSPOSING VARIABLE  
INPUTS INTO SPATIAL DIMENSIONS, USING LASER AS  
LIGHT SOURCE FOR ANTENNA MODELING AND SPECTRUM  
ANALYSIS A65-33770

GROWTH OF NEW CRYSTAL MATERIALS FOR LASERS -  
SPECTRAL ANALYSIS USING FLAME FUSION,  
CZOCHEWSKI, FLUX, AND VAPOR TECHNIQUES  
M7881 N65-19354

THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-19669

THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-21836

SPECTRAL ANALYSIS OF OUTPUT FROM SINGLE CRYSTAL  
SEMICONDUCTOR GENERATOR EXCITED BY ELECTRON  
BEAM - LASERS  
FTD-TT-65-555/16264 N66-12624

## SPECTRAL EMISSION

SHIFT OF EMISSION SPECTRUM IN PULSED GA AS LASER,  
NOTING WAVEFORM CHARACTERISTICS A66-14974

LUMINESCENCE IN RARE EARTH DOPED II-VI COMPOUNDS  
AND SPECTRAL EMISSION CHARACTERISTICS OF LASER  
OSCILLATORS  
ML-1346 N66-16740

SPECTRAL EMISSION CHARACTERISTICS OF LASER  
COHERENT OSCILLATOR N66-16742

## SPECTRAL ENERGY DISTRIBUTION

LIGHT INTENSITY DISTRIBUTION INSIDE CYLINDRICAL  
REFLECTING CAVITY USING RUBY LASER ROD AND  
ANALYSIS OF INTERDEPENDENCE OF THRESHOLD, FILAMENT  
POSITION AND EFFICIENCY A65-22624

## SPECTRAL LINE

SPECTRAL LINE SHAPE FOR FABRY- PEROT MASER USING  
VARIOUS OSCILLATION MODES A65-14113

RUBY LASER POWER DEPENDENCE ON FREQUENCY SPLITTING  
OF TWO COMPONENTS OF R1 DOUBLET AT 77 DEGREES K  
A65-17654

EMISSION AND ABSORPTION PROFILES FOR RUBY R SUB 1  
LINES SHOW ABSENCE OF SIGNIFICANT STOKES SHIFT  
A65-17664

DATA ON LASER MATERIALS REFERENCED TO MAY 1964  
INCLUDING LASER EMISSION LINES AND LASER  
PERFORMANCE PARAMETERS A65-22616

SPECTRAL LINE SHAPE FOR FABRY- PEROT MASER USING  
VARIOUS OSCILLATION MODES A65-24933

NINE ADDITIONAL LASER LINES IN PULSED XENON  
DISCHARGE UNDER CONDITIONS THAT DO NOT PRODUCE  
PREVIOUSLY OBSERVED LINES A65-26953

GAS CONSTITUTION OF HELIUM-NEON LASER DISCHARGE  
ANALYZED, CONSIDERING SPECTRUM LINE RELATIVE  
INTENSITIES IN LIGHT EMITTED FROM DISCHARGE TUBE  
A65-30333

SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE  
LASER, EXAMINING QUESTION OF MODE DECOUPLING  
A65-31306

DISPERSION OF 1.15 MICRON HE- NE LASER LINE  
RESULTING FROM NEON ABSORPTION TRANSITION  
A65-31762

SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE  
LASER, EXAMINING QUESTION OF MODE DECOUPLING  
A65-33352

TIME RESOLVED SPECTROSCOPY OF MERCURY-HELIUM  
DISCHARGE AND 6150 ANGSTROM LASER OSCILLATION,  
EXAMINING METASTABLE ATOM STATE A65-33518

LINE NARROWING OF NEODYMIUM GLASS LASER WITH  
REFLECTION A66-17291

LASER ACTION ON ROTATIONAL LINE IN CARBON DIOXIDE  
AND NITROUS OXIDE VIBRATIONAL SPECTRA IN BOTH P  
AND R BRANCHES UP TO J VALUES OF OVER 50  
A66-23357

## SPECTRAL LINE WIDTH

BRILLOUIN SCATTERING IN LIQUIDS EXCITED BY HE- NE  
MASER AND OBSERVED BY FABRY- PEROT  
INTERFEROMETER, NOTING ACOUSTIC WAVE VELOCITY AND  
LINE BROADENING A65-15699

LASER ACTION THEORY IN CRYSTALLINE OPTICAL SOLID,  
DISCUSSING PROMISING MATERIALS AND MULTIPHONON  
PROCESSES IMPORTANCE IN LINE WIDTH AND TRANSITION  
PROBABILITIES A65-19997

ATOMIC AND MOLECULAR FLUORESCENCE EXCITED BY  
PHOTODISSOCIATION, DISCUSSING LINE STRENGTH AND  
DOPPLER WIDTH A65-20073

SPECTRAL LINE WIDTH NARROWING OF PULSED TRAVELING  
WAVE RUBY LASER OUTPUT  
AD-610865 N65-22139

HEAVY WATER USED AS LIQUID LASER SOLVENT FOR HIGH  
RADIANCE LIQUID LASER SYSTEMS AND RESEARCH IN  
OUTPUT BEAM DIVERGENCE, SPECTRAL NARROWING, AND  
THRESHOLDS FOR LASER ACTION  
AD-610714 N65-27886

WIDTH OF DECAY QUANTA IN GAS LASERS DEPENDS ON  
ENERGIES AND LIFETIMES OF ATOMIC LEVELS INVOLVED



## SPECTROGRAPH

## SUBJECT INDEX

- IN STIMULATED TRANSITIONS AND NONLINEAR RESPONSE  
OF ATOMS A66-12303
- SPECTRAL LINE WIDTH NARROWING IN TRAVELING WAVE  
RUBY LASER CAVITY EMISSION N66-16658
- SPECTROGRAPH**  
USE OF LASER BEAM IN SPECTROGRAPHIC ANALYSIS -  
NORMAL LASER AND GIANT SPIKE LASER  
AFCL-65-586 N66-12799
- SPECTROGRAPHY**  
LASER, MATERIALS, AND SOLID STATE RESEARCH, BAND  
STRUCTURE AND SOLIDS SPECTROGRAPHY, AND  
MAGNETISM AND RESONANCE  
ESD-TDR-64-349 N65-19816
- SPECTROMETER**  
SPECTROMETER FOR LASER OSCILLATION FREQUENCIES AND  
MODES ANALYSIS A65-29430
- ELECTRON PARAMAGNETIC RESONANCE THEORETICAL  
ASPECTS AND APPLICATION TO ATOMIC NUCLEI  
POLARIZATION, INCREASED SPECTROMETER RESOLUTION  
AND SOLID STATE MASERS A65-32773
- PULSE EXCITATION OF VOLUME OF GAS TO COHERENTLY  
RADIATING STATE APPLIED TO BEAM MASER SPECTROMETER  
A66-23731
- SPECTROMETRY**  
CONFERENCE ON CHEMICAL LASERS, UNIVERSITY OF  
CALIFORNIA AT LA JOLLA IN SEPTEMBER 1964  
A65-20059
- NEODYMIUM GLASS LASERS AND GENERATION OF HOLE  
BURNING SPECTRAL FLUXES  
AD-464366 N65-31836
- SPECTROSCOPY**  
LASER APPLICATION IN CHEMICAL COMPOSITION ANALYSIS  
OF MATERIAL BY SPECTROSCOPIC TECHNIQUE,  
CONSIDERING ORGANIC SUBSTANCE AND PLASMA  
A65-20004
- ABSORPTION DATA FOR METHANE AND ETHANE, USING HE-  
NE TUNED LASER SPECTROSCOPY A65-20064
- COLLISION AND POWER BROADENING EFFECTS IN TUNED-  
LASER ABSORPTION SPECTROSCOPY, USING TIME  
DEPENDENT PERTURBATION THEORY A65-20065
- PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J  
AND N TO K CALCULATED WITH GAS LASER  
A65-21811
- PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J  
AND N TO K CALCULATED WITH GAS LASER  
A65-24863
- LASER APPLICATION IN MEDICINE, MANUFACTURING,  
SPECTROSCOPY, OPTICS AND COMMUNICATIONS  
A65-31882
- OPTICAL MASER APPLIED TO BRILLOUIN SCATTERING  
SPECTROSCOPY  
PR-3 N65-13790
- RESEARCH REPORTS ON CODER COMPONENTS, POLYMERS,  
SPECTROSCOPY, LASERS, ELECTROCHEMISTRY,  
TRANSMISSION LINES, AND SEMICONDUCTOR PHYSICS  
NAVWEPS-8150 N65-15565
- MICROWAVE PROBLEMS IN ACOUSTIC WAVE INTERACTIONS,  
TRANSVERSE WAVE ELECTRON BEAM, OPTICAL  
SPECTROSCOPY OF LASER MATERIALS, AND NONLINEAR  
QUANTUM STUDIES  
ML-1243 N65-15605
- SOLID STATE PHYSICS - LASERS, SPECTROSCOPY OF  
SOLIDS, MAGNETISM, AND RESONANCE  
ESD-TDR-64-561 N65-19317
- OPTICAL MASER APPLIED TO BRILLOUIN SCATTERING  
SPECTROSCOPY  
AROD-3922-13 N65-19528
- GASEOUS AND SOLID LASER LINES SURVEY FOR LASER  
SPECTROSCOPY AND PLASMA DIAGNOSTICS
- NASA-CR-57334 N65-19752
- LASERS AND LASER SPECTROSCOPY - LIGHT MODULATION  
AND DEMODULATION METHODS, LASER TRANSITIONS,  
RAMAN EFFECT INITIATION, AND NONLINEAR OPTICAL  
PHENOMENA  
TR-A-34 N65-19791
- RUBY LASER MODULATION AT ATOMIC LEVEL - FREQUENCY  
SHIFT MEASUREMENT OF LASER EMISSION UNDER  
INHOMOGENEOUS MAGNETIC FIELD BY SPECTROSCOPY  
NASA-CR-57464 N65-19863
- SOLID STATE RESEARCH REPORT INCLUDING SOLID STATE  
DEVICES, LASERS, MATERIALS, BAND STRUCTURE,  
MAGNETISM AND RESONANCE, AND SPECTROSCOPY OF  
SOLIDS  
ESD-TDR-65-31 N65-25537
- RESEARCH IN FERROMAGNETISM, POLYMER CHEMISTRY,  
LASERS, SEMICONDUCTORS, AND SOLID STATE  
SPECTROSCOPY  
NAVWEPS-8226 N65-26765
- EXCITED STATE SPECTROSCOPY USING RUBY LASER AND  
LOCALIZED EXCITONS IN ALKALI HALIDES  
AD-619198 N65-35423
- EMISSION SPECTROSCOPY AND COORDINATION CHEMISTRY  
OF EUROPIUM CHELATE SOLUTIONS - CHELATE LASERS  
INVESTIGATED FOR EVALUATING POTENTIALITIES OF  
LIQUID LASERS  
TR-65-052-11 N66-14177
- GROWTH AND ANNEALING OF OPTICAL MASER CRYSTALS AND  
SPECTROSCOPIC EVALUATION OF NEODYMIUM-DOPED  
GLASSES  
PE-TR-8110 N66-17007
- SPHERICAL HARMONICS**  
SPIKING BEHAVIOR OF MULTIMODE RUBY LASER IN  
SPHERICAL RESONATOR, INTERPRETING NEAR-FIELD  
PATTERNS, FREQUENCY SPECTRUM, ETC  
A66-21311
- SPIN**  
TRAVELING WAVE MASER FOR DIRECT MEASUREMENT OF  
CHANGES IN RUBY SPIN TEMPERATURE FOR VARIOUS  
PERTURBATIONS  
NASA-CR-58815 N65-29444
- SPIN-LATTICE RELAXATION**  
MASER ACTION TAKING INTO ACCOUNT MIXING OF  
UNPERTURBED SPIN STATES AND DAMPING MECHANISM  
BETWEEN SPIN MOMENTS AND LOCAL FIELD  
A65-16267
- CONCENTRATION AND TEMPERATURE DEPENDENCE OF SPIN-  
LATTICE RELAXATION TIME IN RUBY AT HELIUM  
TEMPERATURES A66-18257
- CONCENTRATION AND TEMPERATURE DEPENDENCE OF SPIN-  
LATTICE RELAXATION TIME IN RUBY AT HELIUM  
TEMPERATURES A66-20901
- STABILIZATION**  
FREQUENCY STABILIZATION IN VISIBLE SPECTRUM OF  
GAS LASER USED AS OPTICAL PUMP GAIN MODULATOR  
NASA-CR-64359 N65-31013
- STABLE OSCILLATION**  
SELF-PULSED MODULATION MODE STABILIZATION OF TWO-  
LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK A65-14144
- OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER  
BY P-N TRANSITIONS TO INCREASE POWER AND  
DIRECTIVITY OF EMISSION A65-17319
- THREE-LEVEL LASER OUTPUT STABILITY EQUATION  
DERIVED BY NONLINEAR MECHANICS, NOTING LIMIT CYCLE  
AND OSCILLATION STABILITY PRECONDITION  
A65-17514
- SELF-SUSTAINED OSCILLATION OBTAINED IN OPTICALLY  
PUMPED RUBIDIUM MASER OPERATING AT TRANSITION  
FREQUENCY OF 6835 MC A65-21873
- SELF-PULSED MODULATION MODE STABILIZATION OF TWO-

# SUBJECT INDEX

# STIMULATED EMISSION

- LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK A65-24019
- PHOTOBEAT CHARACTERISTICS BETWEEN TWO  
INDEPENDENTLY STABILIZED HE- NE LASERS A65-29117
- OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER  
BY P-N TRANSITIONS TO INCREASE POWER AND  
DIRECTIVITY OF EMISSION A65-30372
- FORMATION TIME OF OPTICAL LASER OSCILLATIONS  
N66-15050
- STANDING WAVE**  
STABILITY AND SOLUTION OF EQUATIONS OF MOTION FOR  
TRAVELING WAVE INTERACTIONS IN LASERS A65-19726
- GASEOUS OPTICAL MASERS CONSIDERING PROBLEM OF  
DOPPLER BROADENED TRANSITION SUBJECTED TO OPTICAL  
FREQUENCY FIELD IN STANDING WAVE FORM A65-24005
- RESONANT WAVES IN FABRY- PEROT INTERFEROMETER  
INVESTIGATED ON BASIS OF STANDING WAVE TYPE  
FORMULATION A65-33516
- STANDING WAVES IN LASER RESONATORS VERIFIED BY  
PLACING THIN METALLIC FILMS BETWEEN EXTERNAL  
MIRRORS OF PULSED NEODYMIUM LASER A66-22893
- STATISTICAL ANALYSIS**  
STATISTICAL MODEL OF RANDOM QUASI-SINUSOIDAL  
FUNCTION OF CONSTANT AMPLITUDE REPRESENTED BY  
EMISSION OF LASER OR RADIO TRANSMITTER A66-18637
- STATISTICAL PROBABILITY**  
STATISTICAL DISTRIBUTION OF ARRIVAL ANGLE, SPOT  
LOCATION, AMPLITUDE, ETC, OF LASER BEAM TRAVERSING  
TURBULENT ATMOSPHERE A65-24931
- STEADY STATE**  
STEADY STATE OSCILLATIONS OF MOLECULAR BEAM LASER  
WITH INHOMOGENEOUS SINUSOIDAL FIELD IN RESONATOR A65-36561
- STEADY STATE OSCILLATIONS OF LASERS WITH  
DISTRIBUTED ENERGY LOSSES N65-27236
- SPATIALLY INDEPENDENT LASER RATE EQUATION  
GENERALIZED FOR MULTIMODE EFFECTS, NOTING STEADY  
STATE OSCILLATION THRESHOLD SINGULARITIES, SPIKING  
PARAMETERS, ETC A66-24560
- TWO-LEVEL ATOM INTERACTION WITH MULTIMODE GAS LASER  
CAVITY, OBTAINING STATIONARY STATE AND SOLVING  
UNIQUE EIGENVALUE IN SPECIAL CASES A66-24568
- STEEL STRUCTURE**  
TREATMENT OF STEEL WITH LASER BEAM, OBTAINING  
PRECISION HOLES WITHOUT AFFECTING MICROHARDNESS OF  
METAL A66-24898
- STEERABLE ANTENNA**  
FACILITIES AND EQUIPMENT AT GOONHILLY DOWNS  
SATELLITE SYSTEM GROUND STATION - STEERABLE  
ANTENNA, COMPUTING AND DATA TRANSMISSION, AND  
HELIUM SYSTEM FOR MASER INSTALLATION N66-10260
- STEERING**  
EFFECTS OF PROPAGATION TIMES ON STEERING NARROW  
BEAM LASER FOR COMMUNICATIONS BETWEEN PLANETARY  
DEEP-SPACE VEHICLE AND EARTH GROUND STATION OR  
RELAY STATION - SPACIAL BEAM OFFSET  
NASA-TM-X-55306 N66-11202
- STIMULATED EMISSION**  
HYPERSONIC WAVES PRODUCED BY BRILLOUIN EFFECT,  
USING METHOD OF TWO INTENSE LIGHT BEAMS A65-14874
- STIMULATED EMISSION EVIDENCE FROM NITROGEN COOLED  
SPIKING RUBY-LASER-IRRADIATED DEGENERATED P-TYPE  
GA AS CRYSTALS A65-15323
- STIMULATED EMISSION OF ELECTROMAGNETIC WAVES FROM  
CIRCULAR CYLINDER AND SPHERE A65-17219
- TIME DEPENDENT VARIATION OF RUBY LASER STIMULATED  
EMISSION INTENSITY A65-19074
- GIANT PULSE LASER APPLIED TO NONLINEAR OPTICAL  
EFFECT OF STIMULATED RAMAN SCATTERING WITH  
REFERENCE TO EMISSION ANGLE MEASUREMENT TECHNIQUE  
A65-19996
- COLLISION AND POWER BROADENING EFFECTS IN TUNED-  
LASER ABSORPTION SPECTROSCOPY, USING TIME  
DEPENDENT PERTURBATION THEORY A65-20065
- CONTINUOUS REGIME OPTICAL GENERATOR OUTPUT,  
THRESHOLD PUMPING LEVEL, INVERSE POPULATION  
DENSITY AND INDUCED RADIATION ENERGY A65-20326
- STIMULATED EMISSION AT ROOM TEMPERATURE IN  
EUROPIUM CHELATE SOLUTION A65-21625
- GAIN NARROWING OF INHOMOGENEOUSLY BROADENED LINE  
IN STIMULATED EMISSION IN LASER AMPLIFIER A65-22615
- TIME DEPENDENCY OF INTENSITY OF STIMULATED  
EMISSION IN RUBY LASER WITH OPTICAL RESONATOR  
CONTAINING ALUMINUM-COATED OPAQUE SPHERICAL  
MIRRORS A65-23014
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH  
RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM  
FLUORIDE DOPED WITH SAMARIUM A65-24085
- STIMULATED EMISSION IN SILICATE GLASS LASER  
CONTAINING NEODYMIUM A65-24189
- PARAMETRIC GAIN ACCOMPANYING PARAMETRIC  
AMPLIFICATION OF LIGHT BEAM BY SECOND HARMONIC  
FREQUENCY OF STIMULATED RADIATION FROM RUBY LASER  
ADP CRYSTALS A65-24280
- PHYSICAL PRINCIPLES OF LASERS AND APPLICATION IN  
STUDYING RADIATION AND MATTER INTERACTION A65-26933
- QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION  
AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION  
A65-28487
- DESIGN, OPERATION AND UTILIZATION OF LASER A65-29867
- MASER PRINCIPLES, PRACTICAL DESIGN AND CURRENT  
APPLICATION A65-30377
- RECOMBINATION RADIATION FROM GALLIUM ANTIMONIDE  
P-N JUNCTIONS, OBSERVING STIMULATED EMISSION AND  
LASER ACTION A65-30572
- Q-SPOILED RUBY LASER BEAM FOCUSED ON GRAPHITE,  
OBTAINING SWAN EMISSION OF CARBON MOLECULE A65-34207
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH  
RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM  
FLUORIDE DOPED WITH SAMARIUM A65-34906
- STIMULATED EMISSION FROM CHROMIUM IONS IN Q-  
SPOILED RUBY LASER A65-35066
- U V RADIATION STIMULATED EMISSION IN OPTICALLY  
PUMPED POTASSIUM BROMIDE CRYSTALS USEFUL FOR LASER  
EMISSION WHICH IS CONSISTENT WITH POPULATION  
INVERSION EXCITON SCHEME A65-35069
- INDUCED RADIATION IN GA AS SEMICONDUCTOR CRYSTAL  
EXCITED BY RUBY LASER WITH Q-MODULATION A65-35842
- HISTORY AND DEVELOPMENT OF MOLECULAR AMPLIFICATION  
BY STIMULATED EMISSION OF RADIATION, NOTING  
VARIOUS LASER TYPES A65-36095
- NONLINEAR OPTICS IN MICROSCOPIC SEARCH FOR ORIGIN  
AND MACROSCOPIC STUDY OF LINKING BETWEEN INCIDENT  
RADIATION AND INDUCED RADIATION

- PHOTON TRANSPORT AND POPULATION INVERSION IN ACTIVE MEDIUM WITH PUMPING EFFECT, CONSIDERING INTENSE BEAM INCIDENCE AND RUBY LASER A65-36219
- STIMULATED EMISSION IN FLUORESCENT ORGANIC MOLECULES N65-15504
- STIMULATED EMISSION FROM GALLIUM ARSENIC P-N JUNCTION LASERS N65-20780
- PRODUCTION OF STIMULATED EMISSION IN BLUE-GREEN REGION IN ORGANIC DOPANT AND HOST SYSTEM - AROMATIC ORGANIC LASER DEVELOPMENT AD-613295 N65-25734
- PROPOSED EXPERIMENT TO OBSERVE STIMULATED PHOTON - PHOTON SCATTERING WITH LASER POWER N65-31459
- SOLID STATE LASERS - PROBLEMS OF CONTINUOUS STIMULATED EMISSION IN SOLIDS, MATERIALS, LIGHT SOURCES, COOLING, AND APPLICATIONS N65-36116
- CURRENT STATUS OF THEORETICAL AND EXPERIMENTAL STUDIES OF VARIANT OF RAMAN EFFECT ENCOUNTERED IN SCATTERING OF LASER LIGHT A66-12065
- QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION A66-12086
- STIMULATED BRILLOUIN AND RAMAN SCATTERING IN GASES, DISCUSSING SOUND VELOCITY CALCULATION FROM FREQUENCY SHIFT AND ARGON, HYDROGEN AND NITROGEN A66-13981
- LASER OSCILLATION IN CALCIUM TUNGSTATE CRYSTALS ACTIVATED WITH TRIVALENT PRASEODYMIUM A66-14898
- HISTORY AND DEVELOPMENT OF MOLECULAR AMPLIFICATION BY STIMULATED EMISSION OF RADIATION, NOTING VARIOUS LASER TYPES A66-15034
- STIMULATED EMISSION IN INDIUM ARSENIDE SHOWS EXCITATION THRESHOLD LOW AND LIGHT EMISSION HIGHLY DIRECTIONAL A66-17026
- OSCILLATION MODE CONTROL IN P-N JUNCTION LASERS FOR CURRENT DENSITY REDUCTION FOR STIMULATED EMISSION A66-17329
- GAS SPECTROSCOPY OF LASER-INDUCED STIMULATED BRILLOUIN EFFECT IN HIGH PRESSURE OXYGEN A66-23432
- RAMAN LASER MATERIALS SELECTION, EMPHASIZING FREQUENCY SHIFTS AND EXCITATION POWER THRESHOLD A66-23477
- HOLE AND ELECTRON SMEARING AND P-TYPE ABSORPTION INFLUENCE ON THRESHOLD CURRENT A66-23478
- POWER AND PATH LENGTH EFFECTS ON STIMULATED RAMAN SPECTRA IN METHANE AND HYDROGEN STUDIES USING GIANT PULSED LASER N66-20037
- ANGULAR DEPENDENCE OBSERVATIONS, ABSORPTION MEASUREMENTS, AND HIGH INTENSITY GAS LASER CONSTRUCTION IN STIMULATED RAMAN EMISSION AND ABSORPTION SPECTROSCOPY STUDY AD-626747 N66-23584
- STOKES LAW**
- EMISSION AND ABSORPTION PROFILES FOR RUBY R SUB 1 LINES SHOW ABSENCE OF SIGNIFICANT STOKES SHIFT A65-17664
- SMALL PARTICLE DETECTION CAPABILITY OF LOW-GAIN HELIUM-NEON GAS LASER ENHANCED BY USE OF STOKES SETTLING LAW AND LAYERED SEDIMENTATION TECHNIQUE A66-14583
- EQUATIONS OBTAINED FROM HAMILTONIAN FOR COUPLING, FIRST STOKES LINE, FIRST ANTI-STOKES LINE AND
- COHERENT FIELD FOR RAMAN LASER A66-22490
- STOKES PARAMETER**
- POLARIZATION OF LIGHT FROM GLASS LASER DOPED WITH TWO PERCENT POSITIVE TRIVALENT NEODYMIUM MEASURED WITH TIME RESOLUTION OF LESS THAN MICROSECOND A66-13006
- STIMULATED RAMAN AND BRILLOUIN SCATTERING FOR STOKES RADIATION PARALLEL TO LASER BEAM IN RECTANGULAR WAVEGUIDE A66-14901
- STORAGE DEVICE**
- HYDROGEN MASER STORAGE BULB CHARACTERISTICS AD-617342 N65-30159
- STORAGE DIODE LASER RESEARCH AD-618297 N65-34108
- STRATOSPHERE**
- RUBY LASER IN OPTICAL RADAR PROBE SYSTEM FOR BALLOON SOUNDING OF STRATOSPHERIC AEROSOL N65-30205
- STREAK PHOTOGRAPHY**
- HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE EXCITATION AND GENERATION KINETICS IN RUBY LASER WITH CONCENTRIC CAVITY A65-18460
- HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE EXCITATION AND GENERATION KINETICS IN RUBY LASER WITH CONCENTRIC CAVITY A65-28089
- STRESS /BIOL/**
- FLUID MECHANICS, LUBRICATION, CORROSION, MASERS, BIOLOGICAL STRESS, PROTECTIVE COATINGS, NEUTRON ACTIVATION, FRACTOGRAPHY, METABOLISM, GUIDED MISSILE LAUNCHING, AND CATAPULTS AD-623630 N66-14468
- STRESS CONCENTRATION**
- DYNAMIC STRESS CONCENTRATION USING PHOTOELASTICITY AND RUBY LASER LIGHT SOURCE TAM-285 N66-20850
- STRESS-OPTIC LAW**
- EFFECT OF COMPOSITION ON THERMAL EXPANSION COEFFICIENT, THERMAL COEFFICIENT OF REFRACTIVE INDEX, BIREFRINGENCE, AND STRESS-OPTICAL COEFFICIENTS FOR ATHERMALIZING LASER GLASS TSR-5 N65-25688
- STRUCTURE**
- LASER, MATERIALS, AND SOLID STATE RESEARCH, BAND STRUCTURE AND SOLIDS SPECTROGRAPHY, AND MAGNETISM AND RESONANCE ESC-TDR-64-349 N65-19816
- SUBHARMONIC OSCILLATOR**
- TWO TYPES OF NONLINEAR INTERACTION OF INTENSE LASER BEAM WITH DIELECTRIC MEDIUM - NONLINEAR CC POLARIZATION AND SUBHARMONICS GENERATION AT OPTICAL FREQUENCIES AD-618473 N65-33899
- SUBMILLIMETER WAVE**
- RUBY AS SUBMILLIMETER MASER MATERIAL, NOTING RELAXATION TIME AND TEMPERATURE CRITERIA A65-26821
- MILLIMETER AND SUBMILLIMETER MASER DEVICES ITR-5 N65-14383
- OPTICAL PUMPING IN DARK RUBY, HARMONIC GENERATION IN HYDROGEN CYANIDE, SUBMILLIMETER WAVE SPECTROSCOPY, AND MIXING OF LASER LIGHT IN BULK PHOTOCONDUCTOR N65-26426
- SULFUR**
- C W LASER ACTION ON TRIPLE STATE PHOSPHORUS-SULFUR TRANSITION, USING HYDROGEN SULFIDE-NOBLE GAS MIXTURES A66-21577
- SUNLIGHT**
- CNE-WATT, ROOM TEMPERATURE, CONTINUOUS OPERATION, SUN PUMPED LASER TRANSMITTER AD-610601 N65-17927

**SUPERCONDUCTING MAGNET**

TRAVELING WAVE MASER EMPLOYING MAGNETIC STAGGER  
TUNING IN SMALL COMPACT SUPERCONDUCTING MAGNET  
ACHIEVES TRADING EXCESS ELECTRONIC GAIN FOR  
BANDWIDTH A65-29196

INERTIAL SENSORS REVIEWING RING LASER,  
ELECTROSTATIC FLUID SPHERE, MAGNETIC RESONANCE,  
SUPERCONDUCTIVITY GYROSCOPE, RELATIVISTIC ROTATING  
TENSOR, VORTEX RATE AND QUANTUM MECHANICAL EFFECT  
SENSING A65-29669

TRAVELING WAVE MASER SUPERCONDUCTING MAGNET  
COOLED IN CLOSED-CYCLE REFRIGERATOR BY THERMAL  
CONDUCTION A65-32128

C-BAND TRAVELING WAVE MASER / TWM/ WITH IRON DOPED  
RUTILE CRYSTAL AND MEANDER LINE SLOW WAVE CIRCUIT  
A65-33373

SUPERCONDUCTORS APPLIED TO MAGNETS, LASERS AND  
MHD POWER GENERATION A66-20674

SUPERCONDUCTING MAGNET FOR VARIABLE BANDWIDTH  
TRAVELING WAVE MASERS, NOTING AMPLIFIER BANDWIDTH  
INCREASE VIA GAIN REDUCTION A66-21417

EASILY FABRICATED LIGHTWEIGHT SUPERCONDUCTING  
MAGNET DESIGNED FOR USE WITH TRAVELING WAVE MASERS  
A66-24312

MULTICOIL SUPERCONDUCTING MAGNETS FOR BROADBAND  
TRAVELING WAVE MASERS NASA-CR-386 N66-18174

**SUPERCONDUCTIVITY**

SUPERCONDUCTING STATES IN IMPURITY-FREE  
SEMICONDUCTORS CREATED BY LASER ILLUMINATION  
A65-28492

SUPERCONDUCTING STATES IN IMPURITY-FREE  
SEMICONDUCTORS CREATED BY LASER ILLUMINATION  
A66-12091

**SUPERHETERODYNE RECEIVER**

OPTICAL SUPERHETERODYNE RECEIVER - LASER SYSTEM,  
DOPPLER FREQUENCY TRACKING, AND OPTICAL  
TRACKING NASA-CR-63393 N65-26401

RADIOMETRIC PERFORMANCE OF SOLID STATE  
SUPERHETERODYNE RECEIVER COMPARABLE TO THAT  
OBTAINED WITH MASERS AND PARAMETRIC AMPLIFIERS  
A66-12437

**SURFACE CRACK**

PARALLEL GROOVES AS SURFACE DAMAGE IN  
SEMICONDUCTORS PRODUCED BY RUBY LASER AS  
DIFFRACTION EFFECT A66-13753

**SURFACE FINISH**

ENERGY OUTPUT INCREASE OF RUBY LASER CRYSTAL  
SYSTEMS BY NUCLEAR ENERGY, LASER CRYSTAL GROWTH,  
AND SURFACE FINISH DEVELOPMENT AD-455571 N65-17595

LASER CRYSTAL GROWTH, CHARACTERIZATION, AND  
SURFACE FINISHING N65-17597

**SURVEILLANCE**

LASER SURVEILLANCE USING OPTICAL BEAM SCANNING FOR  
DETECTION OF SPACE SATELLITES AND BALLISTIC  
MISSILES RADC-TDR-63-557 N65-22210

**SWAN BAND**

Q-SPOILED RUBY LASER BEAM FOCUSED ON GRAPHITE,  
OBTAINING SWAN EMISSION OF CARBON MOLECULE  
A65-34207

**SWITCHING**

RUBY LASER Q-SWITCHING USING PASSIVE SOLID STATE  
OR LIQUID ORGANIC BLUE DYE TO-B-64-15 N65-22933

REPETITIVE HIGH POWER PULSES OBTAINED BY  
Q-SWITCHING OF NEODYMIUM-LOADED YTTRIUM  
ALUMINUM GARNET LASER

CR-6

N65-30870

ROOM TEMPERATURE QUASI-CONTINUOUSLY PUMPED RUBY  
GIANT PULSE LASER WITH SATURABLE ABSORBER Q-  
SWITCH A66-21248

**SWITCHING CIRCUIT**

ELECTRICAL SWITCHING OF EMISSION DIRECTION OF  
LASER OSCILLATOR BY INTERNAL DEFLECTION OF LASER  
BEAM A65-16403

SWITCHING CHARACTERISTICS OF NEGATIVE RESISTANCE  
DIODE DETERMINATION - INJECTION LASER  
REPT.-7 N65-27203

**SWITCHING ELEMENT**

OPTICAL SWITCH WHICH CUTS OFF LASER PULSE WHEN  
SELECTED BEAM POWER LEVEL IS REACHED A65-21626

**SYNCHRONIZED OSCILLATOR**

SYNCHRONIZED MODE OF EXCITATION FOR DIFFRACTION-  
COUPLED LASER A65-28538

SYNCHRONIZED MODE OF EXCITATION FOR DIFFRACTION-  
COUPLED LASER A66-12293

C-SWITCHED OPTICAL MASER SYNCHRONIZATION,  
DISCUSSING EXPERIMENTAL DESIGN, SETUP AND  
PERFORMANCE A66-17297

**SYNTHESIS**

SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION,  
CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION,  
FREQUENCY MODULATION LASERS, AND GALLIUM  
COMPOUND INGOTS FOR LASER APPLICATION  
AFCL-64-1007 N65-23135

**SYSTEMS ANALYSIS**

SYSTEMS ANALYSIS OF LASERS VS MICROWAVES FOR  
MARS-TO- EARTH COMMUNICATIONS IN 1970  
A65-28248

**T**

**TANTALUM**

TANTALUM ELECTRON INDUCED THERMIONIC EMISSION AS  
RESULT OF LASER BEAM BOMBARDMENT A65-24956

RUBY LASER PULSE TECHNIQUE APPLIED TO THERMAL  
DIFFUSIVITY MEASUREMENTS FOR TANTALUM AND  
GRAPHITE CONF-651020-1 N66-18228

**TARGET ACQUISITION**

LASER RANGEFINDER DEVICE PROVIDES FAST AND  
ACCURATE RANGE OF NONCOOPERATIVE TARGETS OPERATING  
ON RADAR PRINCIPLE A65-32586

ACQUISITION, TRACKING AND BEAM POINTING FOR  
OPTICAL COMMUNICATION IN SPACE  
AIAA PAPER 64-420 A65-33536

LASER OPTICAL ALIGNMENT SYSTEM - ALL-WEATHER  
THEODOLITE WITH TARGET-ATTITUDE MEASURING  
CAPABILITY LOPALS-1 N65-20072

**TECTONIC MOVEMENT**

SELECTED FOREIGN SCIENTIFIC AND TECHNICAL  
LITERATURE ON POTENTIAL THEORY, SEMICONDUCTOR  
LASERS, COMPOSITE PROPELLANTS, AROMATIC,  
POLYESTERS, AND TECTONICS N66-21862

**TELECOMMUNICATION**

OPTICAL COHERENT WAVE PROPERTIES SUITABLE FOR LONG  
DISTANCE LASER COMMUNICATIONS AND COMPARED WITH  
RADIO WAVE CHARACTERISTICS A65-20006

LIGHT MODULATION AND LASER TELECOMMUNICATIONS  
NASA-TT-F-8762 N65-32178

**TELEMETRY**

RANGE OF LASER TELEMETRIC DEVICE WITH REFLECTOR  
ON TRACKING OBJECT CNRA-TP-166/1964/ N65-28497

## TEMPERATURE CONTROL

REFRACTIVE INDEX VARIATION DURING LASER OPERATION  
AND CAST-PLASTIC OPTICAL-PUMP CAVITY EQUIPMENT  
FOR PUMPING AND TEMPERATURE CONTROL DURING  
EXPERIMENT  
SATR-1 A65-15753

## TEMPERATURE DISTRIBUTION

PEAK IRRADIANCE OF OPTICAL PUMP AND TOTAL  
PUMP-ENERGY INCIDENT UPON LASER CRYSTAL  
DETERMINED, ACCOUNTING FOR TEMPERATURE VARIATION  
EFFECTS A66-18487

## TEMPERATURE EFFECT

R SUB 1 RUBY LINE EMISSION AND FREQUENCY  
DEPENDENCE ON TEMPERATURE VARIATION A65-15205

LASER BEAM DEFLECTION MODULATION OBTAINED BY  
PASSING CURRENT THROUGH CADMIUM SULFIDE PRISM WITH  
OHMIC CONTACTS, USED FOR THERMOCOUPLE MEASUREMENTS  
A65-25890

WHITE LIGHT EMISSION WHEN PULSED LASER BEAM  
FOCUSES ON TARGETS IS MAINLY DUE TO TEMPERATURE  
RADIATION A65-34957

CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY  
SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY  
LASER A65-35866

HELIUM-NEON GAS LASERS, DISCUSSING AMPLITUDE  
VARIATION SUPPRESSION TECHNIQUE A66-16670

ELECTRON ENERGY SPECTRA IN NEON, XENON AND HELIUM-  
NEON LASER DISCHARGES, CALCULATING PRODUCTION AND  
DESTRUCTION RATE PARAMETERS A66-18354

CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY  
SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY  
LASER A66-19269

## TEMPERATURE GRADIENT

CATHODOLUMINESCENT PHOSPHORS AS LIGHT SOURCE FOR  
LASERS, REDUCING HEAT LIMITATIONS AND ELIMINATING  
INTERNAL STRESSES CAUSED BY THERMAL GRADIENTS  
A65-30436

## TEMPERATURE MEASUREMENT

RUBY LASER TEMPERATURE MEASUREMENT AND FILTERING  
BY DETERMINING SPECTRAL POSITION OF POLARIZATION  
INTERFERENCE BANDS A65-14184

MEASUREMENT OF TEMPERATURE DEPENDENCE OF ENERGY  
LEVELS INVOLVED IN LASER EMISSION  
NASA-CR-64436 A65-32191

RISE OF JUNCTION TEMPERATURE DURING CONTINUOUS  
OPERATION OF GA AS INJECTION LASER A66-14771

TEMPERATURE DEPENDENCE OF EMISSION SPECTRUM AND  
THRESHOLD CURRENT IN GA AS LASERS A66-17333

## TEMPERATURE PROFILE

TEMPERATURE RISE AT GA AS LASER JUNCTION FOR  
VARIOUS PULSE CURRENTS AND BASE TEMPERATURES  
A65-31732

## TERRAIN

GAS LASER RANGE MEASUREMENT DEVICE GIVING HIGH  
ACCURACY DIFFERENTIAL TERRAIN HEIGHT INFORMATION  
FROM AIRBORNE PLATFORM A65-33571

## THEODOLITE

LASER OPTICAL ALIGNMENT SYSTEM - ALL-WEATHER  
THEODOLITE WITH TARGET-ATTITUDE MEASURING  
CAPABILITY  
LOPALS-1 A65-20072

## THERMAL DIFFUSION

RUBY LASER PULSE TECHNIQUE APPLIED TO THERMAL  
DIFFUSIVITY MEASUREMENTS FOR TANTALUM AND  
GRAPHITE  
CONF-651020-1 A66-18228

## THERMAL EFFECT

THERMAL DISTORTION, EXPANSION AND SCATTERING IN  
RUBY AND GLASS LASER RODS DURING AND AFTER PUMP  
FLASH A65-35068

THERMAL LIMITATIONS ON CAPABILITIES OF GALLIUM  
ARSENIDE P-N JUNCTION LASERS A66-10895

BRILLOUIN SCATTERING IN LIQUIDS EXAMINING  
VELOCITY, FREQUENCY AND LIFETIME OF THERMALLY  
EXCITED HYPERSONIC SOUND WAVES, USING LASER LIGHT  
SOURCES A66-12422

## THERMAL EMISSION

LASER SOURCE REFLECTOMETER TO MEASURE REFLECTANCE  
OF SPECIMENS AT HIGH TEMPERATURE - RELATION OF  
THERMAL EMISSION TO OTHER OPTICAL PROPERTIES  
NBS-TN-267 A66-22418

## THERMAL EXPANSION COEFFICIENT

EFFECT OF COMPOSITION ON THERMAL EXPANSION  
COEFFICIENT, THERMAL COEFFICIENT OF REFRACTIVE  
INDEX, BIREFRINGENCE, AND STRESS-OPTICAL  
COEFFICIENTS FOR ATHERMALIZING LASER GLASS  
TSR-5 A65-25688

## THERMAL NOISE

ULTIMATE SENSITIVITY LIMIT AND PHOTOELECTRON  
STATISTICS FOR PHOTOMULTIPLIER LIT BY COHERENT AND  
NONCOHERENT LIGHT A66-12473

CROSS CORRELATION MEASUREMENTS OF OSCILLATOR  
FREQUENCY STABILITY AND THERMAL NOISE AND  
APPLICATION TO ATOMIC HYDROGEN MASER A66-24128

## THERMAL RADIATION

STATISTICS OF MULTIMODE LASER SIGNALS DERIVED AND  
COMPARED WITH THOSE OF INCOHERENT RADIATION  
A65-31034

## THERMIONIC EMISSION

TANTALUM ELECTRON INDUCED THERMIONIC EMISSION AS  
RESULT OF LASER BEAM BOMBARDMENT A65-24956

LINEAR BEAM AND MICROWAVE POWER GENERATION - BEAM-  
CIRCUIT INTERACTION, BASIC CIRCUITS, BEAM-PLASMA  
AMPLIFIER, AND LASER-STIMULATED THERMIONIC  
EMISSION  
RADG-TR-65-22 A65-27099

## THERMOCHEMISTRY

RUBY LASER TEMPERATURE-JUMP RELAXATION KINETIC  
STUDIES OF RAPID REACTIONS  
UUCD-2-64 A66-23078

## THERMOCONDUCTIVITY

THERMAL LIMITATIONS ON CAPABILITIES OF GALLIUM  
ARSENIDE P-N JUNCTION LASERS A66-10895

## THERMODYNAMICS

SOME LASER PROPERTIES FROM VIEWPOINT OF SECOND LAW  
OF THERMODYNAMICS OF IRREVERSIBLE PROCESSES  
A65-31376

SOME LASER PROPERTIES FROM VIEWPOINT OF SECOND LAW  
OF THERMODYNAMICS OF IRREVERSIBLE PROCESSES  
A66-14899

## THERMOELECTRICITY

LOCAL LASER HEATING OF CATHODE FOR ELECTRON  
EXTRACTION FROM PLASMOID A66-16149

## THERMONUCLEAR ENERGY

THERMONUCLEAR FUSION CONTROL FOR ELECTRIC POWER  
CONVERSION - THETA PINCH, ION CYCLOTRON, AND  
INFRARED MASER DIAGNOSTICS A65-24859

## THERMOPHYSICS

THERMOSTIMULATED INDUCED ELECTRON EMISSION FROM  
SAMPLES CUT FROM LASER RUBY CRYSTALS DETECTED WITH  
OPEN POINT COUNTER A66-18609

## THETA PINCH

ELECTRON DENSITY MEASUREMENTS IN PLASMA PRODUCED  
BY COMBINATION OF RF AND VERY FAST THETA-PINCH  
DISCHARGES, USING GAS LASER INTERFEROMETER  
A65-29848

# SUBJECT INDEX

# TIME DEPENDENCY

- TIME-DEPENDENT ELECTRON DENSITY VARIATION STUDIED IN FAST THETA-PINCH DISCHARGE, USING HE-NE GAS LASER INTERFEROMETER A65-29849
- THERMONUCLEAR FUSION CONTROL FOR ELECTRIC POWER CONVERSION - THETA PINCH, ION CYCLOTRON, AND INFRARED MASER DIAGNOSTICS N65-24859
- FLUORESCENT ORGANIC LASER DEVELOPMENT - THETA PINCH ARGON LAMP MEASUREMENTS QR-7 N65-25966
- LOCAL ELECTRON TEMPERATURE AND ELECTRON DENSITY IN THETA PINCH MEASURED BY MEANS OF SCATTERING OF LASER BEAM A66-14334
- LASER PUMPING TECHNIQUES - THETA PINCH ENERGY TRANSFER EFFICIENCY IN CONVERSION OF ELECTRIC ENERGY TO ELECTROMAGNETIC ENERGY AFOSR-65-2212 N66-15605
- THIN FILM**
- PROCESSING EVAPORATED CADMIUM SULFIDE THIN FILMS TO ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING LASER-INDUCED ELASTIC VIBRATIONS A65-21875
- LASER MICROWELDING EVALUATION WITH REGARD TO BONDING OF DISSIMILAR ELECTRONIC INTERCONNECTION MATERIALS FOR THIN FILM CIRCUITS A65-24352
- OPTICAL COATING REQUIREMENTS OF LASERS WITH RESPECT TO MATERIALS AND MULTILAYER CONFIGURATION A65-29528
- EVAPORATED CADMIUM SULFIDE THIN FILMS PROCESSED TO ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING LASER-INDUCED ELASTIC VIBRATION A65-31942
- HELIUM-NEON GAS LASER AS LIGHT SOURCE FOR MAGNETO-OPTICAL APPARATUS - KERR MAGNETO-OPTICAL EFFECT OF FERROMAGNETIC IRON-NICKEL THIN FILM N65-26766
- FOREIGN SCIENCE BULLETIN - GIANT RADIO TELESCOPE RAMAN SCATTERING LASERS - FORECASTING SOLAR FLARES - MAN-IN-SPACE - EPITAXIAL GROWTH OF ALUMINUM NITRIDE THIN FILMS - TECHNOLOGY N65-30979
- GIANT RADIO TELESCOPE TO DETECT EXTRATERRESTRIAL RADIATION, RAMAN SCATTERING LASERS, FORECASTING SOLAR FLARES FOR MANNED SPACE FLIGHT, VOSKHOD II LIFE SUPPORT, AND ALUMINUM NITRIDE FILMS N65-32675
- ELECTRONIC DEVICES - DUPLEXERS, PLASMA AMPLIFIERS, CATHODE RAY TUBES, CAPACITORS, THIN FILM TECHNIQUES, AND OPTICAL MASERS SR-85 N65-33773
- TRIMMING MICROCIRCUIT ELEMENTS LIKE EVAPORATED THIN-FILM AND SILK-SCREENED CERMET-FILM RESISTORS ATTEMPTED WITH CW AND PULSED LASERS A66-14562
- THOMSON EFFECT**
- THOMSON SCATTERED LASER RADIATION USED TO DETERMINE ELECTRON DENSITY IN HELIUM PLASMA, EXAMINING THYRATRON TUBE AND VOLTAGE PROBE USE A65-19618
- LASER MODE OPERATION IN PRESENCE OF RADIATION ABSORBING IMPURITY ANALYZED BY EXTENDED THOMSON TYPE SYSTEM A65-35930
- THRESHOLD**
- OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF SOLID STATE LASER AND COMPENSATION VIA LENS IN RESONATOR A65-36051
- OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF SOLID STATE LASER AND COMPENSATION VIA LENS IN RESONATOR A66-15854
- THRESHOLD CURRENT**
- HEAVY WATER USED AS LIQUID LASER SOLVENT FOR HIGH RADIANCE LIQUID LASER SYSTEMS AND RESEARCH IN OUTPUT BEAM DIVERGENCE, SPECTRAL NARROWING, AND THRESHOLDS FOR LASER ACTION AD-610714 N65-27886
- U V AND VISIBLE LASER OSCILLATIONS IN FLUORINE, PHOSPHORUS AND CHLORINE ATOMS IN PULSED CHLORINE, PHOSPHORUS FLUORIDE AND SULFUR FLUORIDE GAS DISCHARGES A66-10972
- GALLIUM ARSENIDE P-N JUNCTION LASER DIODE COVERING INJECTION CURRENT DISTRIBUTION, DENSITY AND EMISSION SPECTRA VARIATION A66-14659
- TEMPERATURE DEPENDENCE OF EMISSION SPECTRUM AND THRESHOLD CURRENT IN GaAs LASERS A66-17333
- HOLE AND ELECTRON SMEARING AND P-TYPE ABSORPTION INFLUENCE ON THRESHOLD CURRENT A66-23478
- THRESHOLD GATE**
- THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION RESONATOR A66-19669
- THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION RESONATOR A66-21836
- THRESHOLD SHIFT**
- OPTICAL AND LASER THRESHOLD MEASUREMENTS ON 39 FLAME-FUSION RUBIES TO OBTAIN HIGHEST OPTICAL QUALITY LASER RODS A65-16402
- THRUSTOR**
- ELECTRON AND ION EMISSION FROM PULSED RUBY LASER ILLUMINATED METALLIC SURFACE INTO VACUUM, DETERMINING APPLICATION TO PULSED ION THRUSTOR AIAA PAPER 66-230 A66-21453
- THULIUM**
- LASER CHARACTERISTICS OF AND COHERENT OSCILLATIONS FROM TRIVALENT TM, HO, YB AND ER IONS IN YTTRIUM ALUMINUM GARNET A66-10241
- THUNDERSTORM**
- RESEARCH IN CHINESE PEOPLES REPUBLIC - SOLAR FLUX, GAS DISCHARGE TUBE, NEODYMIUM LASER, GEOLOGICAL MECHANICS, MICROCRYSTALLINE GLASS, LOCATING OF THUNDER, AND PURIFICATION WITH DISTILLATION METHODS JPRS-33759 N66-16806
- TIME CONSTANT**
- INTERNAL LOSSES EFFECT ON RADIATION POWER IN LASER A65-24058
- TIME DELAY**
- TIME CORRELATION BETWEEN LASER PULSES AND LASER-INDUCED ELECTRON EMISSION FROM METALLIC SURFACES A65-34616
- LASERS AS TRIGGERING MECHANISM FOR SPARK GAPS, NOTING DELAY TIME BETWEEN PULSE ARRIVAL AND CURRENT FLOW A66-13247
- TIME DEPENDENCY**
- TIME DEPENDENT VARIATION OF RUBY LASER STIMULATED EMISSION INTENSITY A65-19074
- TIME DEPENDENCY OF INTENSITY OF STIMULATED EMISSION IN RUBY LASER WITH OPTICAL RESONATOR CONTAINING ALUMINUM-COATED OPAQUE SPHERICAL MIRRORS A65-23014
- TEMPORAL DEPENDENCE IN LASER INDUCED GAS DISCHARGES REPT.-1935-2 N65-21555
- RUBY LASER WITH VIBRATING MIRROR FOR STUDY OF TEMPORAL OUTPUT MEASUREMENTS N65-22759
- PUMP POWER DEPENDENCE OF RUBY LASER STARTING AND STOPPING TIME PREDICTED VIA RATE EQUATION ANALYSIS A66-21309
- TIME DEPENDENCY OF COUPLED MODE LASER OSCILLATION UCRL-7497 N66-20355

## TIME FUNCTION

PHOTOTUBE OBSERVATION OF RUBY LASER OUTPUT  
AS FUNCTION OF TIME N65-15570

IONIZATION PHENOMENA IN ARGON DUE TO LASER  
RADIATION BY MEASURING ELECTRON DENSITY AND ENERGY  
AS TIME FUNCTION AFTER LASER PULSE INITIATION AT  
DIFFERENT GAS PRESSURES AND PREIONIZED CONDITIONS  
AIAA PAPER 66-176 A66-21690

## TIME MEASUREMENT

ATOMIC HYDROGEN MASER FOR TIME AND FREQUENCY  
MEASUREMENTS - TIME COMPARISONS ON MASERS WITH  
LORAN C N65-26678

CAVITY TUNING OF AMMONIA MASERS BY PRESSURE AND  
ZEEMAN EFFECT MODULATION N65-26684

## TIME RESPONSE

TIME RESPONSE OF HF LASER INTERFEROMETER USED IN  
PLASMA RESONANCE DETECTION A65-29791

TIME DEPENDENT EMISSION BEHAVIOR OF RUBY LASER  
DISCUSSING RATE EQUATIONS, Q-VALUE, OUTPUT POWER,  
STEADY STATE VALUES, ETC A66-14981

CROSS CORRELATION MEASUREMENTS OF OSCILLATOR  
FREQUENCY STABILITY AND THERMAL NOISE AND  
APPLICATION TO ATOMIC HYDROGEN MASER

A66-24128

## TISSUE

SOLID STATE LASERS, ACOUSTICS, AND REGENERATION OF  
MUSCLE TISSUE - TRANSLATIONS OF CHINESE  
PEOPLES REPUBLIC ARTICLES ON SCIENCE AND  
TECHNOLOGY  
JPRS-31817 N65-36115

RETINAL VASCULATURE OF RABBIT AND MONKEY AS  
AFFECTED BY LASER IRRADIATION PROXIMITY OF  
PIGMENT EPITHELIUM, BLOOD FLOW, AND AMOUNT OF  
REDUCED HEMOGLOBIN A66-80470

## TITANIUM COMPOUND

HIGH INTENSITY LOW VOLTAGE DISCHARGE RESULTING  
FROM RUBY LASER BEAM FOCUSING ON TITANIUM HYDRIDE  
TARGET A65-24282

## TOROIDAL DISCHARGE

PLASMA RING DISCHARGE EXCITATION USED TO DRIVE  
HIGH CURRENT DENSITY ELECTRODELESS ARC FOR  
EXCITING GAS ION LASER TRANSITIONS

A66-10967

## TORSIONAL VIBRATION

GAS EFFECTS PRODUCED BY PULSED LASER BEAM IN  
BALLISTIC TORSIONAL PENDULUM PHOTOMETER, NOTING  
DEFLECTION DUE TO PHOTON MOMENTUM EXCHANGE

A65-32229

## TRACKING ANTENNA

RADIO STATION FACILITIES AT RAISTING, WEST  
GERMANY NOTING SATELLITE COMMUNICATION, MASER  
RECEIVING SYSTEM, PARABOLIC ANTENNAS, ETC

A65-35195

## TRACKING STATION

LASER BEAM COMMUNICATION BETWEEN DEEP-SPACE  
VEHICLE AND EARTH TRACKING STATION - CLOSED LOOP  
SYSTEM AND LEAD ANGLE COMPUTATIONS FOR TARGET  
MOTION COMPENSATION  
NASA-CR-60699

N65-16811

## TRAINING EQUIPMENT

PULSED LASER FOR SIMULATING TANK GUN FIRING FOR  
TRAINING OF TANK GUNNERS  
NAVTRADEVEN-1311-1

N65-34674

## TRANSIENT RESPONSE

BUILDUP AND DECAY TRANSIENT EFFECTS IN GAS LASERS  
DUE TO LIGHT ABSORPTION BY INSERTED LIQUID SAMPLES

A65-15816

## TRANSISTOR CIRCUIT

RADIATION PROTECTIVE DRUGS, XENON AND HELIUM-  
XENON LASERS, HELIUM-NEON LASER WITH SILVER AND  
DIELECTRIC COATINGS, AND TRANSISTOR CIRCUITS  
JPRS-29200

N65-20134

QUANTUM ELECTRODYNAMICS IN OPTICAL RESONATORS AND  
MASERS, THERMAL PINCHING, N-TYPE SEMICONDUCTORS,  
COHERENT LIGHT, TRANSISTOR SWITCHING, POPULATION  
INVERSION, AND BREAKDOWN  
AFOSR-65-0248 N65-23491

GA AS OPTICALLY COUPLED TRANSISTOR STRUCTURE WITH  
LASING EMITTER A66-12442

## TRANSITION ELEMENT

SPECTROSCOPIC DATA ON ABSORPTION, SPONTANEOUS  
FLUORESCENCE AND STIMULATED EMISSION IN ACTINIDES,  
TRANSITION METAL AND SEMICONDUCTOR LASER MATERIAL  
A65-21168

## TRANSITION POINT

LASER TRANSITION IN VIBRATIONAL STATE OF GROUND  
ELECTRONIC STATE OF CN FROM ROTATIONAL LEVEL 8 TO  
7 WITH POPULATION INVERSION AS RESULT

A66-11451

## TRANSITION PROBABILITY

TRANSITION PROCESSES OF OSCILLATION AMPLITUDE  
FORMATION IN RF THREE-LEVEL MASERS

A65-15460

STATIONARY AND TRANSIENT LIGHT AMPLIFICATION  
REGIMES IN ACTIVE MEDIA OPERATING ACCORDING TO  
FOUR-LEVEL SCHEME A65-18455

LASER ACTION THEORY IN CRYSTALLINE OPTICAL SOLID,  
DISCUSSING PROMISING MATERIALS AND MULTIPHONON  
PROCESSES IMPORTANCE IN LINE WIDTH AND TRANSITION  
PROBABILITIES A65-19997

MEASUREMENT OF GAS LASER RADIATIVE DECAY RATES AND  
TOTAL INELASTIC DESTRUCTIVE CROSS SECTION OF SHORT  
LIVED EXCITED STATES IN 4-NSEC TO 1000-NSEC RANGE  
A65-20061

PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J  
AND N TO K CALCULATED WITH GAS LASER  
A65-21811

PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J  
AND N TO K CALCULATED WITH GAS LASER  
A65-24863

STATIONARY AND TRANSIENT LIGHT AMPLIFICATION  
REGIMES IN ACTIVE MEDIA OPERATING ACCORDING TO  
FOUR-LEVEL SCHEME A65-28084

TRANSITION PROCESSES OF OSCILLATION AMPLITUDE  
FORMATION IN RF THREE-LEVEL MASERS

A65-28556

TRANSITION PROBABILITIES FOR AR II LASER LINES  
COMPARED WITH PREVIOUS THEORETICAL AND  
EXPERIMENTAL DATA A65-29799

LASER ACTION IN SECOND POSITIVE BAND SYSTEM OF  
MOLECULAR NITROGEN, OBSERVING SATURATION OF  
TRANSITION A65-33049

## TRANSLATION

EFFECT OF HIGH VELOCITY TRANSLATION ON PHOTON  
CORRELATIONS IN LASER INTERFEROMETERS  
UCRL-14345

N66-10969

## TRANSMISSION LINE

INSTABILITY IN LASER AMPLIFIER MEDIUM OCCURRING AT  
HIGH PUMPING LEVELS, GIVING TRANSMISSION LINE  
EQUIVALENT CIRCUIT FOR PLANE WAVE PROPAGATION  
A65-25888

RESEARCH REPORTS ON CODER COMPONENTS, POLYMERS,  
SPECTROSCOPY, LASERS, ELECTROCHEMISTRY,  
TRANSMISSION LINES, AND SEMICONDUCTOR PHYSICS  
NAVWEPS-8150 N65-15565

## TRANSMISSION LOSS

REABSORPTION AS DOMINANT LOSS MECHANISM FOR BCTH  
INCOHERENT AND COHERENT RADIATION IN GALLIUM  
ARSENIDE LUMINESCENT DIODE A65-30347

## TRANSMITTER

GNE-WATT, ROOM TEMPERATURE, CONTINUOUS OPERATION,  
SUN PUMPED LASER TRANSMITTER  
AD-610601 N65-17927

# SUBJECT INDEX

# TRAVELING WAVE MASER

- DESIGN OF COMPACT 100 WATT GALLIUM ARSENIDE LASER TRANSMITTER N65-20177
- DOPPLER OPTICAL NAVIGATOR TO MEASURE INSTANTANEOUS GROUND SPEED WITH 0.1 FT/SEC ACCURACY FOR ALTITUDES OF 250 TO 5000 FEET - CONTINUOUS WAVE LASER AS TRANSMITTER TRG-019-1-2 N65-28160
- SUN-POWERED LASER TRANSMITTER DEVELOPMENT - RUBY, NEODYMIUM-DOPED GLASS, AND NEODYMIUM-DOPED CALCIUM TUNGSTATE LASER MATERIALS IER-1 N65-29901
- OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER AS TRANSMITTER AND SILICON P-I-N PHOTODIODE AS DETECTOR USED AS AIRCRAFT ALTIMETER N66-11665
- TRANSVERSE OSCILLATION**
- TRANSVERSE MODES OF LASER ANALYZED WITH SCANNING INTERFEROMETER BY MATCHING RESPECTIVE MODES OF TWO DEVICES A65-29531
- TRANSVERSE WAVE**
- FREQUENCY SEPARATION BETWEEN TRANSVERSE MODES OF RUBY LASER MEASURED BY FABRY-PEROT INTERFEROMETER AND VERIFIED BY TRANSVERSE MODE SELECTION A65-27610
- MICROWAVE PROBLEMS IN ACOUSTIC WAVE INTERACTIONS, TRANSVERSE WAVE ELECTRON BEAM, OPTICAL SPECTROSCOPY OF LASER MATERIALS, AND NONLINEAR QUANTUM STUDIES ML-1243 N65-15605
- EXPERIMENTS ON OPERATING LIFE AND TRANSVERSE MODE HOPPING IN CONTINUOUS WAVE RUBY LASER IER-7 N65-33421
- INTENSITY DISTRIBUTION OF FRINGE SYSTEMS USED TO VERIFY PHASE INVERSION BETWEEN TWO LOBES OF LASER IN TEM-10 MODE A66-17453
- TRAPPED RADIATION**
- RESONANCE RADIATION TRAPPING BETWEEN LOWER LASER LEVEL AND ION GROUND STATE AS MECHANISM FOR QUENCHING AND RING-SHAPED BEAM FORMATION IN ION LASERS A65-26004
- IMPROVED QUANTUM EFFICIENCY FROM LIGHT TRAPPED IN TRANSLUCENT PHOTOCATHODE LASER DETECTORS ITIL-66-1002 N66-20166
- TRAPPING**
- DYNAMICS AND CHARACTERISTICS OF SELF-TRAPPING OF INTENSE LIGHT BEAMS NASA-CR-74030 N66-23765
- TRAVELING WAVE**
- STABILITY AND SOLUTION OF EQUATIONS OF MOTION FOR TRAVELING WAVE INTERACTIONS IN LASERS A65-19726
- POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR A65-36058
- SPECTRAL LINE WIDTH NARROWING OF PULSED TRAVELING WAVE RUBY LASER OUTPUT AD-610865 N65-22139
- PARAMETRIC EXCITATION OF ACOUSTIC WAVES IN SIMULATED BRILLOUIN SCATTERING REPT.-1935-5 N65-29906
- TRAVELING WAVE OSCILLATIONS IN RUBY LASER RESONATOR USING PASSIVE OPTICAL ISOLATOR, ELIMINATING FARADAY ROTATOR AND ATTENDANT MAGNETIC FIELD A66-11448
- MODEL FOR BEHAVIOR OF OPTICAL MASER IN STATIC MAGNETIC FIELD OF ARBITRARY STRENGTH IN Z DIRECTION AND IN ELECTROMAGNETIC FIELD COMPOSED OF TRAVELING WAVES A66-13135
- POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR A66-15861
- TIME RESOLVED INTERFEROMETRY, CINEMATOGRAPHY, AND TRAVELING WAVE CAVITY STUDIES ON RUBY LASERS AFCRL-65-467 N66-16656
- SPECTRAL LINE WIDTH NARROWING IN TRAVELING WAVE RUBY LASER CAVITY EMISSION N66-16658
- TRAVELING WAVE AMPLIFIER**
- PLANE STATIONARY MODE OF TW LASER AMPLIFIER WITH FEEDBACK A65-19683
- TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN 8-CM BAND A65-24882
- TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN 8-CM BAND A65-36359
- NONLINEAR PROPAGATION OF PULSE SIGNAL IN LASER TYPE TRAVELING WAVE AMPLIFIER A66-11841
- APPLICATION, PROBLEMS AND STATE OF LOW NOISE AMPLIFIERS AND TRAVELING WAVE TUBES, MASER AND ADLER TUBES GAIN IN RADAR SYSTEMS A66-14123
- NONLINEAR EFFECTS IN TRAVELING WAVE LASER AMPLIFIERS AFCSR-65-0999 N66-10779
- TRAVELING WAVE MASER**
- LOW NOISE KA-BAND TRAVELING WAVE MASER AMPLIFIER FOR WINDOW AT 8 MM WHERE ATMOSPHERIC ATTENUATION IS LOW A65-16565
- TRAVELING WAVE MASER FOR TELSTAR AND RELAY SATELLITES, DISCUSSING ELECTRONICS AND SOLID STATE PHYSICS PRINCIPLES AND DESIGN A65-16798
- MICROWAVE PROPERTIES PARTICULARLY LINEWIDTH AND MAGNETIC ANISOTROPY IN CALCIUM-VANADIUM BISMUTH GARNET, NOTING TWM ISOLATOR A65-24964
- TRAVELING WAVE MASER EMPLOYING MAGNETIC STAGGER TUNING IN SMALL COMPACT SUPERCONDUCTING MAGNET ACHIEVES TRADING EXCESS ELECTRONIC GAIN FOR BANDWIDTH A65-29196
- LOCK-ON BAND OF CONTINUOUSLY OPERATING LASER OSCILLATOR DETERMINED FOR TRAVELING WAVE CIRCUIT A65-30070
- NOISE OUTPUT AND NOISE FACTOR OF OVERLOADED MASER AMPLIFIERS STUDIED AS FUNCTION OF SMALL-SIGNAL GAIN VS ACTUAL GAIN A65-31032
- SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-31306
- TRENDS IN MASER AMPLIFIERS, DESCRIBING TYPES AND DEVELOPMENT TECHNIQUES A65-31408
- TRAVELING WAVE MASER SUPERCONDUCTING MAGNET COOLED IN CLOSED-CYCLE REFRIGERATOR BY THERMAL CONDUCTION A65-32128
- FORWARD TRAVELING COHERENT ACOUSTIC WAVE AND BACKWARD TRAVELING ELECTROMAGNETIC WAVE PRODUCED IN STIMULATED BRILLOUIN SCATTERING OF INTENSE LASER BEAM A65-32745
- SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-33352
- C-BAND TRAVELING WAVE MASER / TWM/ WITH IRON DOPED RUTILE CRYSTAL AND MEANDER LINE SLOW WAVE CIRCUIT A65-33373
- TRUNCATED EQUATIONS DESCRIBING COHERENT RADIATION OF EXCITED CHROMIUM IONS IN RUBY SITUATED IN TRAVELING WAVE RESONATOR A65-35919
- TRAVELING WAVE MASER FOR DIRECT MEASUREMENT OF CHANGES IN RUBY SPIN TEMPERATURE FOR VARIOUS PERTURBATIONS NASA-CR-58815 N65-29444



COMPUTER ANALYSIS DETERMINING CHANGE OF POPULATION INVERSION AND OUTPUT PHOTON FLUX AND EXPERIMENT USING RUBY FOR OSCILLATOR AND AMPLIFIER USING TRAVELING WAVE MASER IN TRIANGULAR CONFIGURATION  
GSP/PHYS/65-14 N65-31091

DEVELOPMENT AND APPLICATION OF IMPROVED MASER TECHNIQUES FOR BROADBAND MASER SYSTEM - TRAVELING WAVE MASER TECHNIQUES  
RADC-TR-65-148 N65-32203

SOLID-STATE AND TRAVELING-WAVE MASER TECHNIQUES  
RADC-TR-65-30 N65-33397

MILLIMETER AND SUBMILLIMETER MASER DEVICES - MEASURING TECHNIQUES FOR ZERO FIELD MASER REPT.-490G N65-33895

DESIGN OF 8 MILLIMETER TRAVELING WAVE MASER FOR RADIO ASTRONOMY  
AD-619191 N65-35172

INDUCED EMISSION MODES OF TRAVELING WAVE LASER  
A66-10778

WIDE TUNING RANGE L-BAND TRAVELING WAVE MASER NOTING SLOW WAVE STRUCTURE AND ISOLATOR MATERIAL  
A66-12441

TRAVELING FIELDS IN INTERACTION OF IONIZED GASES WITH ELECTROMAGNETIC FIELD CURRENTS CHECKING LORENTZ FORCE AND MAGNETIC INDUCTION  
A66-12980

FABRY-PEROT INTERFEROMETER AND CONFOCAL AND SPHERICAL RESONATOR, CALCULATING INTEGRAL EQUATIONS FOR EIGENVALUE AND EIGENFUNCTION OF LOWEST ORDER TW EIGENMODE  
A66-14277

TRAVELING WAVE OSCILLATIONS OF ION RING LASER IN MIRROR-RING RESONATOR  
A66-14903

EXPERIMENTAL L-BAND TRAVELING WAVE MASER DEVELOPED WITH EXCEPTIONALLY WIDE TUNING RANGE  
A66-15958

L-BAND TRAVELING-WAVE MASER FOR RADIO ASTRONOMY RESEARCH AT 21 CM USES CHROMIUM-DOPED RUTILE  
A66-16640

LOCK-ON BAND OF CONTINUOUSLY OPERATING LASER OSCILLATOR DETERMINED FOR TRAVELING WAVE CIRCUIT  
A66-17623

SUPERCONDUCTING MAGNET FOR VARIABLE BANDWIDTH TRAVELING WAVE MASERS, NOTING AMPLIFIER BANDWIDTH INCREASE VIA GAIN REDUCTION  
A66-21417

GC/S NITROGEN-COOLED NONDEGENERATE PARAMETRIC AMPLIFIER, NOTING DESIGN, APPLICATION AND OPERATION CHARACTERISTICS  
A66-21857

INDUCED EMISSION MODES OF TRAVELING WAVE LASER  
A66-22290

EASILY FABRICATED LIGHTWEIGHT SUPERCONDUCTING MAGNET DESIGNED FOR USE WITH TRAVELING WAVE MASERS  
A66-24312

BROADBAND TRAVELING WAVE MASER TECHNIQUES AND N-TYPE GERMANIUM SEMICONDUCTOR DEVELOPMENT  
RADC-TR-65-366 N66-15720

MULTICOIL SUPERCONDUCTING MAGNETS FOR BROADBAND TRAVELING WAVE MASERS  
NASA-CR-386 N66-18174

#### TRAVELING WAVE TUBE

TRAVELING-WAVE TUBE WITH PHOTOELECTRIC CATHODE USED AS DEMODULATOR FOR LASER COMMUNICATION  
A65-14345

NOISE BEHAVIOR OF POTENTIAL MINIMUM OF TRAVELING WAVE TUBES AND REDUCTION FACTOR FOR SHOT NOISE DETERMINED, USING LASERS  
A65-26936

ELECTRONICS RESEARCH ON TRAVELING WAVE TUBES, RARE EARTH TARGETS FOR NEUTRON GENERATORS, AND GAS DISCHARGE AND SEMICONDUCTOR

INJECTION-TYPE LASERS N65-20166

#### TRIANGULATION

OPTICAL TRACKING OF SATELLITES EQUIPPED FOR GEODETIC TRIANGULATION, USING GROUND LASER BEAMS  
A65-29936

#### TRIPLET EXCITATION

PULSED MOLECULAR NITROGEN LASER THEORY VIA ELECTRON IMPACT EXCITATION OF TRIPLET STATES  
A65-33050

#### TROPOSCATTER

LASER BEAM BEYOND-HORIZON COMMUNICATION BY MEANS OF CLOUD AND HAZE SCATTERING  
A65-19596

SEMICONDUCTOR LASERS, FM TECHNIQUES AND MULTIPLE-SCATTER PATHS USED TO OVERCOME MODULATION NOISE UNDER VARYING WEATHER CONDITIONS  
A66-19915

#### TUNGSTATE

STUDIES ON RADIATION PROTECTION FOR MAN, OPTICAL MASER OF NEODYMIUM IN TUNGSTATE, CYLINDER WAVE PROPAGATION ANALYSIS, AND ELECTROMOTIVE FORCE OF INDIUM ANTIMONIDE COMPOUND  
JPRS-33152 N66-15042

OPTICAL MASER OF TRIVALENT NEODYMIUM IN TUNGSTATE CRYSTALS  
N66-15045

#### TUNGSTEN

ENERGY MEASUREMENT OF RUBY LASER INDUCED ELECTRON EMISSION FROM TUNGSTEN  
A65-20241

CONTINUOUSLY PULSED LASER DEVICE WITH SELF-CONTAINED LASER OSCILLATOR AND POWER SUPPLY - LASER HEADS USING TUNGSTEN LAMPS AND XENON FLASHLAMPS FOR PUMP EXCITATION  
REPT.-2 N65-27581

PULSED XENON FLASHLAMP AND CONTINUOUS INCANDESCENT TUNGSTEN LAMP TRADEOFFS AS NEODYMIUM-YTTRIUM ALUMINUM GARNET CRYSTAL LASER PUMPS  
REPT.-3 N65-30242

#### TUNING

INTERNAL TUNING METHODS FOR CONTINUOUS WAVE LASERS OVER ANGSTROM BANDWIDTHS  
SEL-64-092 N65-14369

CAVITY TUNING OF AMMONIA MASERS BY PRESSURE AND ZEEMAN EFFECT MODULATION  
N65-26684

TWO-FREQUENCY VOLUME RESONATOR WITH INDEPENDENT TUNING WITHIN WIDE FREQUENCY BAND  
A66-18918

#### TUNNELING

SOLID STATE AND MASER TECHNIQUES - BREADBOARD EVALUATION, MEASUREMENTS OF LOW-TEMPERATURE SEMICONDUCTOR, AND SUPERCONDUCTING THIN FILM TUNNELING EFFECTS  
RADC-TR-64-480 N65-16017

## U

#### U.S.S.R.

LASER RESEARCH IN U.S.S.R., COMBUSTION INSTABILITY IN LIQUID ROCKET AND AIR BREATHING PROPULSION, GAS DYNAMICS AND PROPERTIES AT HIGH TEMPERATURE, AND MORPHOLOGICAL FORMS IN POLYMERS  
AD-460286 N65-23836

#### ULTRAHIGH VACUUM

INTERACTION MECHANISM BETWEEN LASER BEAM AND SURFACE IN ULTRAHIGH VACUUM  
A66-15484

#### ULTRASONIC LIGHT MODULATOR /ULM/

RUBY LASER OSCILLATIONS MODULATED BY ULTRASONIC VIBRATION  
A65-19623

OPTICAL BEAM SCANNING AND LASER OUTPUT MODULATION BY MEANS OF ULTRASONIC CELL BUILT AROUND FOCUSING CYLINDRICAL SECTION TRANSDUCER  
A65-28419

WIDEBAND LASER BEAM MODULATION, USING BRAGG-ANGLE DIFFRACTION BY AMPLITUDE-MODULATED ULTRASONIC WAVES  
A65-29974

# SUBJECT INDEX

# VIBRATION MODE

- ULTRASONIC LASER MODULATION TECHNIQUES  
C-920259-3 N65-18440
- LIGHT OUTPUT FROM HELIUM-NEON GAS MASER  
PHOTOGRAPHED WITH AND WITHOUT INTRACAVITY  
MODULATION AT LOCKING FREQUENCY, USING HIGH SPEED  
ROTATING MIRROR A66-17205
- MODULATING OUTPUT OF SOLID-STATE LASERS  
D-920259-12 N66-12814
- ULTRASONIC WAVE  
HYPERSONIC WAVES PRODUCED BY BRILLOUIN EFFECT,  
USING METHOD OF TWO INTENSE LIGHT BEAMS A65-14874
- BRILLOUIN SCATTERING IN LIQUIDS EXCITED BY HE- NE  
MASER AND OBSERVED BY FABRY- PEROT  
INTERFEROMETER, NOTING ACOUSTIC WAVE VELOCITY AND  
LINE BROADENING A65-15699
- HYPERSONIC WAVE GENERATION BY SUPERPOSITION OF  
TWO COHERENT LIGHT BEAMS IN SOLID OR LIQUID  
DIELECTRIC A65-15880
- POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY  
ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR  
A65-36058
- USE OF REFRACTIVE INDEX VARIATION CAUSED BY  
PROPAGATION OF ULTRASONIC WAVES IN LASER  
FEEDBACK INTERFEROMETER TO CONTROL LASER OUTPUT  
C-920083-12 N65-15207
- POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY  
ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR  
A66-15861
- ULTRASONIC WAVE TRANSDUCER  
EFFICIENT DIFFRACTION OF INCIDENT LASER BEAM AT  
BRAGG ANGLE INCIDENCE INTO FIRST-ORDER MODE,  
USING TRAVELING ULTRASONIC WAVES IN WATER A65-33057
- ULTRAVIOLET LIGHT  
LASER PRODUCTION OF HARD ULTRAVIOLET LIGHT FOR  
STUDYING LIGHTNING AND ATMOSPHERIC PROPAGATION  
LET-417 N65-14074
- INTENSE UV PUMPING EFFECT ON RUBY LASER OUTPUT  
A66-20519
- ULTRAVIOLET RADIATION  
U V ION LASER TRANSITIONS IN INERT GASES, OXYGEN  
AND NITROGEN BETWEEN 2300 AND 4000 ANGSTROMS,  
SHOWING RELATIONSHIP BETWEEN GAIN AND TUBE  
DIAMETER A65-27334
- U V RADIATION STIMULATED EMISSION IN OPTICALLY  
PUMPED POTASSIUM BROMIDE CRYSTALS USEFUL FOR LASER  
EMISSION WHICH IS CONSISTENT WITH POPULATION  
INVERSION EXCITON SCHEME A65-35069
- HIGH INTENSITY ULTRAVIOLET RADIATION SOURCE TO  
PUMP PHOSPHORS AND LASER MATERIALS WITH  
ABSORPTION BANDS IN PHOSPHOR EMISSION SPECTRUM  
DDRF-173 N65-14365
- EFFECTS OF INTENSE ULTRAVIOLET RADIATION ON GLASS  
MATERIALS, AND PERFORMANCE CHARACTERISTICS OF  
GLASS LASERS  
AD-623309 N66-14533
- UPPER ATMOSPHERE  
UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE  
RUBY LASER TECHNIQUES, PRESENTING HEIGHT  
DISTRIBUTION CURVES OF SCATTERED LIGHT A66-13376
- V
- VACUUM MELTING  
ELECTRON BEAM MELTING HEAT SOURCE IN VACUUM  
METALLURGY, AND RUBY AND NEODYMIUM GLASS LASERS  
FOR INDUSTRY N65-23723
- VACUUM PUMP  
AMMONIA MASER - AMMONIA MOLECULAR GENERATOR  
FTD-TT-65-803/14264 N66-19855
- VACUUM ULTRAVIOLET  
RELATION BETWEEN 600 ANGSTROM EMISSION BAND OF  
HELIUM MOLECULE AND IMPRISONMENT OF NEON RESONANCE  
LINES MEASURED TO SHOW EFFECT ON HELIUM-NEON LASER  
OPERATION A65-34662
- VANADIUM  
MICROWAVE PROPERTIES PARTICULARLY LINEWIDTH AND  
MAGNETIC ANISOTROPY IN CALCIUM-VANADIUM BISMUTH  
GARNET, NOTING TWM ISOLATOR A65-24964
- VAPOR  
GALLIUM ARSENIDE ALLOY INGOT PREPARATION BY  
VAPOR TRANSPORT METH-CDS FOR LASER APPLICATIONS  
N65-23139
- VAPOR DEPOSITION  
VAPOR PHASE GROWTH OF RUBY SINGLE CRYSTALS FOR  
LASER APPLICATIONS  
AD-629154 N66-23875
- VAPORIZATION  
HEATING AND VAPORIZATION EFFECTS DUE TO HIGH POWER  
LASER BEAM ABSORPTION AT OPAQUE SURFACES, NOTING  
ALSO Q-SWITCHED LASERS A65-17663
- MATERIAL VAPORIZATION BY Q-SPOILED LASER PULSES  
FOR SPECTROSCOPIC ANALYSIS OF VAPOR OPTICAL  
EMISSION AND ABSORPTION PROPERTIES  
AFCL-64-871 N65-22274
- VAPORIZATION HEAT  
INTERACTION OF LIGHT PULSE FROM RUBY LASER WITH  
MERCURY SURFACE, OBSERVING MECHANICAL IMPACT  
BELIEVED TO BE RAPID VAPORIZATION PROCESS A66-14373
- VASCULAR SYSTEM  
RETINAL VASCULATURE OF RABBIT AND MONKEY AS  
AFFECTED BY LASER IRRADIATION PROXIMITY OF  
PIGMENT EPITHELIUM, BLOOD FLOW, AND AMOUNT OF  
REDUCED HEMOGLOBIN A66-80470
- VELOCITY DISTRIBUTION  
HIGHER ORDER CALCULATION OF LASER OUTPUT, NOTING  
APPROXIMATION METHOD FOR LINEWIDTH PARAMETER AND  
LAMB DIP SHAPE ACCURACY A66-19063
- VELOCITY MEASUREMENT  
RELATIVITY VELOCITY SENSING TECHNIQUE FOR MOVING  
VEHICLE BY LASER LIGHT BACKSCATTERED FROM SURFACE  
A65-14934
- OPTICAL DIFFRACTION VELOCIMETER LASER NAVIGATION  
SYSTEM A65-29275
- MOVING SURFACE VELOCITY MEASUREMENT USING LASER  
RADIATION  
GE/EE/64-18 N65-17373
- DIFFRACTION VELOCIMETER DETECTING AND MEASURING  
TRANSVERSE MOVEMENT OF SURFACE BY SENSING LIGHT  
BACKSCATTERED BY IT WHEN LASER ILLUMINATED  
A66-18333
- OPTICAL DIFFRACTION VELOCIMETER, USING  
BACKSCATTERED LASER LIGHT TO MEASURE RELATIVE  
VELOCITY BETWEEN LIGHT SOURCE AND SURFACE  
A66-22958
- CONTINUOUS WAVE GAS LASER DOPPLER FLOW METER FOR  
GAS VELOCITY MEASUREMENT N66-22338
- VERNEUIL TECHNIQUE  
GROWTH OF RUBY BOULES ON 60 DEGREE VERNEUIL RODS  
BY CZOCHRALSKI METHOD - LASER APPLICATION  
SRCR-65-1 N65-27885
- VIBRATION MODE  
KINETIC EQUATION TO DESCRIBE CONTINUOUS WAVE LASER  
RADIATION INSTABILITY A65-19739
- OSCILLATION CHARACTERISTICS OF RUBY LASER WITH  
EXTERNAL MIRRORS OF LARGE SPACING  
A65-33517
- PROPERTIES OF FREQUENCY MODULATION AND SUPER MODE  
LASER  
IER-1 N66-10766

# VIBRATIONAL FREQUENCY

# SUBJECT INDEX

## VIBRATIONAL FREQUENCY

FEASIBILITY OF LASER OPERATING ON VIBRATIONAL -  
TRANSITIONS - SCHEMES USING FRANCK- CONDON  
PRINCIPLE  
VARIAN-314-35 N65-28168

## VIBRATIONAL RELAXATION

RELAXATION OSCILLATIONS IN FOUR-LEVEL SOLID STATE  
LASER STUDIED VIA DIFFERENTIAL EQUATIONS,  
CALCULATING SHAPE AND ENVELOPE OF OSCILLATION  
A65-30574

VIBRATIONAL AND ROTATIONAL RELAXATIONS IN CARBON  
DIOXIDE AND NITROUS OXIDE LASER SYSTEMS, USING Q-  
SWITCHING TECHNIQUES A66-23355

## VIBRATIONAL SPECTRUM

C W LASER OSCILLATION ON P BRANCH ROTATIONAL  
TRANSITIONS OF VIBRATION BAND OF NITROUS OXIDE  
A65-16671

PARTIAL AND COMPLETE VIBRATIONAL-ROTATIONAL  
POPULATION INVERSION CONDITIONS, DISCUSSING  
VIBRATIONAL STATE CHANGE IN PHYSICAL AND CHEMICAL  
PROCESSES A65-20067

C W HIGH POWER OPERATION OF NITROGEN-CARBON  
DIOXIDE LASER OSCILLATING ON P-BRANCH ROTATIONAL  
TRANSITIONS OF VIBRATIONAL BAND OF CARBON DIOXIDE  
A65-33055

LASER ACTION ON P- AND R-BRANCH TRANSITIONS OF  
CARBON DIOXIDE VIBRATIONAL SPECTRUM BAND PRODUCED  
BY PULSED DISCHARGE ADMIXTURE OF VARIOUS GASES  
A65-33058

LASER ACTION ON ROTATIONAL TRANSITIONS OF 10-9, 9-  
8, 8-7, 7-6 AND 6-5 VIBRATIONAL BANDS OF GROUND  
ELECTRONIC STATE CO A66-18424

LASER ACTION ON ROTATIONAL LINE IN CARBON DIOXIDE  
AND NITROUS OXIDE VIBRATIONAL SPECTRA IN BOTH P  
AND R BRANCHES UP TO J VALUES OF OVER 50  
A66-23357

## VISIBLE RADIATION

LASER OSCILLATION IN VISIBLE REGION FROM PULSED  
COLD CATHODE DISCHARGE IN IONIZED S AND P  
A65-33379

VISIBLE DISCHARGES INDUCED IN GASES BY FOCUSED  
RUBY LASER PULSES  
REPT.-1579-14 N65-14982

## VISIBLE SPECTRUM

BROADBAND DIELECTRIC MIRRORS USED WITH PULSED GAS  
LASER TO OBSERVE LASER OSCILLATIONS IN VISIBLE  
WAVELENGTH REGION A65-16570

LASER OSCILLATION IN VISIBLE SPECTRA OF SINGLY  
IONIZED ZINC AND CADMIUM OBTAINED WITH PULSED  
DISCHARGES IN HEATED VAPORS OF THESE METALS MIXED  
WITH NOBLE GASES A65-32747

FREQUENCY STABILIZATION IN VISIBLE SPECTRUM OF  
GAS LASER USED AS OPTICAL PUMP GAIN MODULATOR  
NASA-CR-64359 N65-31013

SPECTROSCOPY OF HIGH POWER GAS LASER EMISSION  
IN VISIBLE SPECTRUM FROM CW ARGON, KRYPTON,  
XENON, AND MERCURY-HELIUM LASERS  
QPR-3 N65-31202

OUTPUT SPECTRA OF ARGON ION LASER IN RING  
RESONATOR AND TWO MIRROR RESONATORS  
A66-14904

## VISUAL DISPLAY

LASER BEAM MODULATING TECHNIQUES AND SCANNING  
DEVICE TO FORM OPTIMAL VISUAL DISPLAYS  
RADC-TDR-64-365 N65-20562

## VISUAL PERCEPTION

VISUAL PERCEPTION OF INTENSE COHERENT IR  
RADIATION FROM GAS LASER A65-24083

VISUAL PERCEPTION OF INTENSE COHERENT IR  
RADIATION FROM GAS LASER A65-34904

VISUAL PERCEPTION OF INFRARED LASER EMISSION  
NASA-TT-F-9888 N66-22300

## VOICE COMMUNICATION

ELECTRODELESS EXCITATION OF DISCHARGE IN HELIUM-  
NEON GAS LASER TUBE APPLIED TO VOICE TRANSMISSION  
A66-14924

## VOLT-AMPERE CHARACTERISTICS

CURRENT-VOLTAGE CHARACTERISTICS OF CW X-BAND  
GA AS MICROWAVE GUNN GENERATOR  
A66-23029

## VOLTAGE BREAKDOWN

BREAKDOWN OF GASES UNDER INFLUENCE OF LASER SPARK  
PHENOMENA WITH SUBSEQUENT ABSORPTION OF LASER  
RADIATION AND GAS HEATING A66-10646

## VOSKHOD II SPACECRAFT

GIANT RADIO TELESCOPE TO DETECT EXTRATERRESTRIAL  
RADIATION, RAMAN SCATTERING LASERS, FORECASTING  
SOLAR FLARES FOR MANNED SPACE FLIGHT, VOSKHOD  
II LIFE SUPPORT, AND ALUMINUM NITRIDE FILMS  
N65-32675

## W

## WATER

GREEN LASER LIGHT TRANSMISSION THROUGH WATER  
NOLTR-64-179 N65-20605

HEAVY WATER USED AS LIQUID LASER SOLVENT FOR HIGH  
RADIANCE LIQUID LASER SYSTEMS AND RESEARCH IN  
OUTPUT BEAM DIVERGENCE, SPECTRAL NARROWING, AND  
THRESHOLDS FOR LASER ACTION  
AD-610714 N65-27886

COMPARISON OF UNDERWATER ATTENUATION OF RUBY  
LASER LIGHT WITH NONLASER LIGHT  
NRL-6181 N65-28158

## WATER VAPOR

PULSED WATER VAPOR LASER FOR FAR IR GIVING DESIGN  
AND PERFORMANCE A65-22626

MEASUREMENT OF VERTICAL WATER VAPOR PROFILES BY  
MEANS OF THERMALLY TUNED RUBY LASER OPTICAL  
RADAR SYSTEM - HUMIDITY MEASUREMENT  
REPT.-65-6 N66-14852

## WAVE

GROWTH OF WAVES IN PULSED LASER AMPLIFIER  
CALCULATED USING QUASI ONE-DIMENSIONAL MODEL -  
AMPLIFICATION OF EXTERNALLY IMPRESSED AND  
SPONTANEOUSLY EMITTED WAVES  
AVCO-EVERETT RES. REPT.-233 N66-10972

SPONTANEOUS EMISSION FROM ATOM INTERACTING WITH  
COHERENT LIGHT WAVE  
AFOSR-65-1000 N66-12043

## WAVE ATTENUATION

COMPARISON OF UNDERWATER ATTENUATION OF RUBY  
LASER LIGHT WITH NONLASER LIGHT  
NRL-6181 N65-28158

## WAVE DIFFRACTION

MONOGRAPH ON THEORY OF COHERENCE IN OPTICS  
INCLUDING CONCEPT OF DEGREE IN COHERENCE,  
COHERENCE IN QUASI-MONOCROMATIC LIGHT AND IN  
DIFFRACTION PHENOMENA A65-33897

SYNCHRONIZED GENERATION OF RADIATION BY ALL  
SEMICONDUCTOR ELEMENTS OF LASER SYSTEM WITH  
RADIATIVE MIRRORS CAUSED BY DIFFRACTION OF  
ELECTROMAGNETIC FIELD A65-35279

TIME DEPENDENT EMISSION BEHAVIOR OF SINGLE AXIAL  
MODE OF DIFFRACTION LIMITED RUBY LASER AT ROOM  
TEMPERATURE A66-20420

## WAVE EQUATION

OBLATE SPHERICAL CAVITY MODE APPROACH TO MODE  
STRUCTURE OF LASER RESONATOR, USING VECTOR WAVE  
EQUATION A65-22932

## WAVE EXCITATION

LASER EXCITATION IN QUARTZ OF ELASTIC MODES OF  
THICK PLATE, SUGGESTING ENERGY COUPLING MECHANISMS

# SUBJECT INDEX

WIRE

A66-12423

A66-19922

## WAVE FRONT

PUMP TRANSFORMER LASERS - CONVERSION TO SINGLE  
PLANE-WAVEFRONT BY ABSORPTION AND RE-EMISSION  
OF MOLECULAR GAS MEDIUM  
GPL-A-31-1

N65-35530

WAVELENGTH MEASUREMENT OF HELIUM-NECN LASER  
EMISSION BY DOUBLE-CHANNEL RECORDING  
INTERFEROMETER, USING KRYPTON-86 PRIMARY STANDARD  
A66-22874

## WAVE FRONT RECONSTRUCTION

LASER APPLICATION PROBLEMS IN INTERFEROMETRY,  
RADAR AND HOLOGRAPHY INCLUDING MECHANICAL  
STABILITY, NOISE SUPPRESSION, DIRTY LASER BEAM  
RESTORATION, ETC  
A66-11454

MODE-CONTROLLED GIANT PULSE LASER USED TO PRODUCE  
TWO-BEAM HOLOGRAM IN SHORT EXPOSURE TIME OF 30  
NSEC  
A66-12215

## WEATHER FORECASTING

UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE  
RUBY LASER TECHNIQUES, PRESENTING HEIGHT  
DISTRIBUTION CURVES OF SCATTERED LIGHT  
A66-13376

## WEATHER RADAR

MASER PREAMPLIFIER DESIGNED INTO X-BAND WEATHER  
RADAR SET INCREASED RADAR SENSITIVITY BY 12.5  
DECIBELS TO OVERALL 110.5 DECIBELS  
A66-13688

LASER RADAR AS INSTRUMENT TO OBTAIN OPERATIONAL  
METEOROLOGICAL INFORMATION  
A66-21067

EVALUATION OF MASER-EQUIPPED WEATHER RADAR SET AND  
AREA PRECIPITATION MEASUREMENT INDICATOR -  
METEOROLOGICAL SENSING DEVICE - ELECTRONICS  
GPR-1  
N66-14191

MASER EQUIPPED WEATHER RADAR AND PRECIPITATION  
MEASUREMENT INDICATOR  
GPR-2  
N66-19957

## WELDED JOINT

LASER WELDING TECHNIQUE EXAMINING JOINT DESIGN,  
WELDABLE MATERIALS AND COSTS  
A65-32798

LASER BEAM WELDING ELECTRONIC-COMPONENT LEADS  
A66-14517

## WELDED STRUCTURE

HIGH POWERED LASERS AND LASER WELDING  
NASA-TM-X-53285  
N65-28961

## WELDING

LASER MICROWELDING EVALUATION WITH REGARD TO  
BONDING OF DISSIMILAR ELECTRONIC INTERCONNECTION  
MATERIALS FOR THIN FILM CIRCUITS  
A65-24352

ESTIMATION OF ENERGY PARAMETERS OF LASER LIGHT  
BEAM USED TO WELD METALS  
A65-30071

LASERS FOR MACHINING AND WELDING, NOTING  
PARTICULARLY HE- NE PULSED LASER  
A65-30540

PRODUCTION LASER WELDING OF INTRICATE AND CRITICAL  
SUBASSEMBLIES INCORPORATED INTO SPACE VEHICLES AND  
COMPONENTS  
A66-14514

HEATING PROCESS IN LASER WELDING OF METAL SHEETS,  
TAKING INTO ACCOUNT ENERGY DISTRIBUTION, HEAT  
TRANSFER AND FLUX DENSITIES  
A66-15347

ESTIMATION OF ENERGY PARAMETERS OF LASER LIGHT  
BEAM USED TO WELD METALS  
A66-17626

LASER WELDING FOR PRODUCTION MICROWELDING, NOTING  
DESIGN, CONSTRUCTION AND APPLICATION  
ASTME PREPRINT MM66-707  
A66-24415

LASER TECHNIQUES FOR WELDING POLYTHERMALESE COATED  
MAGNET WIRE TO STAINLESS STEEL AND GOLD PLATED  
NICKEL TERMINALS  
NASA-CR-70935  
N66-19615

## WELDING MACHINE

PULSED LASER WELDING, WIRE-TO-WIRE, SHEET-TO-  
SHEET, CIRCUIT BOARD, VACUUM TUBE, ETC  
A66-18153

## WIGNER COEFFICIENT

QUANTUM STATISTICAL PROCEDURE DEVELOPED FOR  
RADIATION FIELD AND APPLIED TO LASER AMPLIFIERS  
A65-32707

## WIRE

LASER TECHNIQUES FOR WELDING POLYTHERMALESE COATED  
MAGNET WIRE TO STAINLESS STEEL AND GOLD PLATED  
NICKEL TERMINALS

NASA-CR-70935

N66-19615

## X

## X-BAND

ZERO FIELD X-BAND MASER DESIGN FOR MICROWAVE QUANTUM AMPLIFIERS - MILLIMETER AND SUBMILLIMETER WAVE DEVICES  
REPT.-490F N65-25851

MASER PREAMPLIFIER DESIGNED INTO X-BAND WEATHER RADAR SET INCREASED RADAR SENSITIVITY BY 12.5 DECIBELS TO OVERALL 118.5 DECIBELS  
A66-13688

CURRENT-VOLTAGE CHARACTERISTICS OF CW X-BAND GA AS MICROWAVE GUNN GENERATOR  
A66-23029

## X-RAY INSPECTION

RUBY LASER CRYSTALS GROWN BY FLAME-FUSION, FLUX AND CZOCHRALSKI METHOD EXAMINED FOR PERFECTION BY X-RAY TOPOGRAPHY AND DOUBLE-CRYSTAL ROCKING CURVES  
A66-13744

## XENON

EXCITATION MECHANISMS IN XENON AND HELIUM-XENON GAS LASERS  
S-705 N65-15980

RADIATION PROTECTIVE DRUGS, XENON AND HELIUM-XENON LASERS, HELIUM-NEON LASER WITH SILVER AND DIELECTRIC COATINGS, AND TRANSISTOR CIRCUITS  
JPRS-29200 N65-20134

CONTINUOUSLY PULSED LASER DEVICE WITH SELF-CONTAINED LASER OSCILLATOR AND POWER SUPPLY - LASER HEADS USING TUNGSTEN LAMPS AND XENON FLASHLAMPS FOR PUMP EXCITATION  
REPT.-2 N65-27581

EXCITATION MECHANISMS IN XENON AND HELIUM-XENON GAS LASER, XENON LIFETIMES, AND THEORY OF DIFFUSION CONTROLLED GLOW DISCHARGE  
S-669 N65-28779

STUDY OF PARAMETERS OF HIGH GAIN 2.026 MICRON XENON-HELIUM LASER TO OPTIMIZE POWER OUTPUT AND EFFECT OF TUBE DIAMETER ON SMALL SIGNAL GAIN  
WRE-PAD-104 N65-28901

PULSED XENON FLASHLAMP AND CONTINUOUS INCANDESCENT TUNGSTEN LAMP TRADEOFFS AS NEODYMIUM-YTTRIUM ALUMINUM GARNET CRYSTAL LASER PUMPS  
REPT.-3 N65-30242

OPACITY MEASUREMENT OF XENON FLASH TUBE - OPTICAL MASER  
NASA-CR-56917 N65-35256

MULTIPHOTON IONIZATION OF XENON ATOM IN POWERFUL ELECTRIC FIELD BY RUBY LASER RADIATION  
A66-21966

XENON FLASH TUBE FIRING SYSTEM FOR LASERS  
BNL-9257 N66-20553

## XENON LIGHT

NINE ADDITIONAL LASER LINES IN PULSED XENON DISCHARGE UNDER CONDITIONS THAT DO NOT PRODUCE PREVIOUSLY OBSERVED LINES  
A65-26953

TWO BREWSTER-TYPE LASERS IN OSCILLATOR-AMPLIFIER CONFIGURATION USED TO MEASURE LASER GAIN IN XENON-KRYPTON DISCHARGE  
A65-34610

STIMULATED EMISSION OF LIGHT FROM PURE XENON AND HELIUM-XENON  
N65-20135

BALLOON-BORNE XENON LIGHT OPTICAL BEACON FOR LASER AND OPTICAL TRACKING, AND MISSILE-BORNE XENON OPTICAL BEACON FOR OPTICAL TRACKING  
B-3068 N65-31897

INFLUENCE OF RESONANT CAVITY, XENON LIGHT, AND OTHER PARAMETERS ON RUBY LASER EMISSION ENERGY OUTPUT  
FTD-TT-64-1339/1&2&3&4 N66-11522

## Y

## YTTERBIUM

YB3- ER3 GLASS THREE LEVEL LASER ACTION  
A65-17208

LASER CHARACTERISTICS OF AND COHERENT OSCILLATIONS FROM TRIVALENT TM, HO, YB AND ER IONS IN YTTRIUM ALUMINUM GARNET  
A66-10241

## YTTRIUM-ALUMINUM GARNET /YAG/ CRYSTAL

COHERENT HIGH POWER PULSES FROM OPTICALLY PUMPED Y A G- ND LASER BY Q-SWITCHING FROM MIRROR ROTATION  
A65-26003

LASER MODULATION AT ATOMIC LEVEL - YTTRIUM-ALUMINUM GARNET EMISSION AND LASER EMISSION SHIFT WITH HOMOGENEOUS PULSED MAGNETIC FIELD  
NASA-CR-57823 N65-21308

PULSED XENON FLASHLAMP AND CONTINUOUS INCANDESCENT TUNGSTEN LAMP TRADEOFFS AS NEODYMIUM-YTTRIUM ALUMINUM GARNET CRYSTAL LASER PUMPS  
REPT.-3 N65-30242

REPETITIVE HIGH POWER PULSES OBTAINED BY Q-SWITCHING OF NEODYMIUM-LOADED YTTRIUM ALUMINUM GARNET LASER  
CR-6 N65-30870

LASER CHARACTERISTICS OF AND COHERENT OSCILLATIONS FROM TRIVALENT TM, HO, YB AND ER IONS IN YTTRIUM ALUMINUM GARNET  
A66-10241

SOLID STATE OPTICAL MASER RESEARCH - YTTRIUM-ALUMINUM-GARNET NEODYMIUM LASER OSCILLATOR AS REGENERATIVE NOISE AMPLIFIER - AMPLITUDE FLUCTUATIONS  
LR-7 N66-14272

## Z

## ZEEMAN EFFECT

INTERFEROMETER TUNING EFFECT ON ZEEMAN BEAT FREQUENCY IN RADIATION OF HELIUM-NEON LASER WITH APPLIED MAGNETIC FIELD  
A65-26956

ZEEMAN EFFECT IN PARAMAGNETIC CRYSTALS BY RUBY FOR MICROWAVE MODULATION OF PULSED LASER BY ABSORPTION  
A65-32746

ELECTRON PARAMAGNETIC RESONANCE THEORETICAL ASPECTS AND APPLICATION TO ATOMIC NUCLEI POLARIZATION, INCREASED SPECTROMETER RESOLUTION AND SOLID STATE MASERS  
A65-32773

LASER MODULATION AT ATOMIC LEVEL - POPULATION INVERSION AND ESTIMATE OF ZEEMAN SPLITTING  
NASA-CR-60572 N65-16320

CAVITY TUNING OF AMMONIA MASERS BY PRESSURE AND ZEEMAN EFFECT MODULATION  
N65-26684

ZEEMAN EFFECT MODULATION OF AMMONIA MASER FOR FREQUENCY STANDARD  
N65-26685

NONLINEAR ZEEMAN EFFECT FOR GAS LASER  
A66-19638

RESONATOR MADE OF MAGNETIC MATERIALS FOR TUNING MOLECULAR GENERATOR BY ZEEMAN MODULATION  
A66-20792

SIMULTANEOUS ACTION OF RF PERTURBATION BETWEEN ZEEMAN SUBLEVELS OF ATOMIC TRANSITION WHICH IS ALSO PRODUCING LASER OSCILLATION  
A66-21177

LONGITUDINAL MAGNETIC FIELD EFFECT UPON GAS DISCHARGE, ZEEMAN EFFECT AND FARADAY EFFECT IN HE- NE GAS LASER  
A66-24224

DEPENDENCE OF EMISSION INTENSITY OF GAS LASER ON LONGITUDINAL AND TRANSVERSE MAGNETIC FIELDS, USING SIMPLIFIED MODEL  
A66-24885

## ZINC

RESONANT ENERGY TRANSFER FROM MERCURY TO ZINC IN

**SUBJECT INDEX**

**ZINC SULFIDE**

GAS LASER  
AD-603680 N65-14200

GALLIUM ARSENIDE LASER DIODES FABRICATED BY  
DIFFUSION OF ZINC  
QPR-1 N65-17442

ZINC DIFFUSION IN GALLIUM ARSENIDE-PHOSPHIDE  
LASERS AND EFFECTS ON SEMICONDUCTOR JUNCTIONS  
AFCRL-66-18 N66-22611

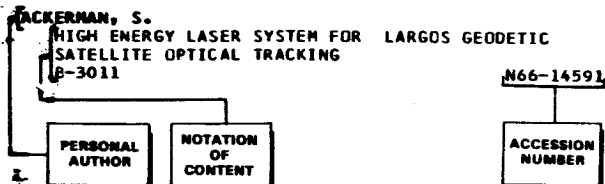
ZINC SULFIDE  
PHOTOLUMINESCENCE LINE STRUCTURE OF ZINC SULFIDE  
AND CADMIUM SULFIDE CRYSTALS DOPED WITH RARE  
EARTHS - LASER MATERIALS N66-16741

# Personal Author Index

LASERS AND MASERS / a continuing bibliography with indexes

JULY 1966

## Typical Personal Author Index Listing



A Notation of Content (NOC), rather than the title of the document, is used to provide a more exact description of the subject matter. The accession number is included to assist the user in locating the abstract in the abstract section.

## A

ABELLA, I. D.  
PHOTON ECHO, SHORT PULSE OF LIGHT SPONTANEOUSLY  
EMITTED BY DILUTE RUBY CRYSTAL AFTER RUBY-LASER  
PULSE IRRADIATION A66-18442

ABRAHAM, R. K.  
CHORIORETINAL LESIONS PRODUCED BY LASER ON MONKEY  
AND RABBIT A66-80950

ACKERMAN, J. A.  
ADAPTABILITY OF LASERS TO SCHLIEN SYSTEMS -  
PHOTOGRAPHIC LIGHTING SYSTEMS ARL-65-139 N66-14801

ACKERMAN, S.  
HIGH ENERGY LASER SYSTEM FOR LARGOS GEODETIC  
SATELLITE OPTICAL TRACKING B-3011 N66-14591

ACTON, C. V.  
LOWER ATMOSPHERE ABSORPTION SPECTRUM STRUCTURE  
FROM 8512 TO 11600 A - NEODYMIUM LASER SPECTRUM  
NRL-6352 N66-17604

ADAMS, C. M., JR.  
LASER BEAM MACHINING AND DRILLING TECHNIQUES FOR  
USE ON ANY MATERIAL REGARDLESS OF THERMAL  
PROPERTIES A65-25373

ADAMS, N. I.  
OPTICAL MARGINAL OSCILLATOR DEVELOPMENT IN  
RESEARCH TOWARD TUNABLE COHERENT LIGHT SOURCE  
REPT.-8071 N66-14034

ADELMAN, A. H.  
TANTALUM ELECTRON INDUCED THERMIONIC EMISSION AS  
RESULT OF LASER BEAM BOMBARDMENT A65-24956

LASER BEAM INTERACTION WITH METAL FORM OF  
THERMAL, MULTIPLE PHOTON AND ELECTRIC FIELD EFFECT  
A65-27427

ADRIANOVA, I. I.  
POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY  
ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR  
A65-36058

POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY  
ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR  
A66-15861

AFANASEV, A. M.  
SECOND HARMONIC LIGHT GENERATION IN CADMIUM  
SULFIDE CRYSTAL NEAR ABSORPTION BAND A65-21056

SECOND HARMONIC LIGHT GENERATION IN CADMIUM  
SULFIDE CRYSTAL NEAR ABSORPTION BAND A65-31220

AGABEKIAN, A. S.  
SELF-PULSED MODULATION MODE STABILIZATION OF TWO-  
LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK A65-14144

SELF-PULSED MODULATION MODE STABILIZATION OF TWO-  
LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK A65-24019

AGESHIN, F. S.  
FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS  
SYSTEMS, PRIMARILY LIGHT ABSORPTION AND  
ATMOSPHERIC SCATTERING A65-15349

FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS  
SYSTEMS, PRIMARILY LIGHT ABSORPTION AND  
ATMOSPHERIC SCATTERING A65-32353

AHLSTROM, E. R.  
RUBY LASER WITH VIBRATING MIRROR FOR STUDY OF  
TEMPORAL OUTPUT MEASUREMENTS N65-22759

AMMED, S. A.  
MICROWAVE ELECTRON CYCLOTRON RESONANCE PUMPING OF  
NEON-HELIUM LASER TO RAISE PLASMA ELECTRON  
TEMPERATURE FOR INCREASE OF OUTPUT A65-15320

AIGRAIN, P.  
SOLID STATE LASERS WITH EMPHASIS ON PUMPING  
MECHANISMS, SEMICONDUCTOR DEVICES AND IMPURITY-  
MATRIX SYSTEMS A65-24007

AITKEN, E. D.  
ARC-TUBE CONSTRUCTED FOR COOLING ARGON ION  
LASER - DISCHARGE TUBE  
GE/EE/65-1 N66-14188

AKHMANOV, S. A.  
OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING  
POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED  
POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-15352

OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING  
POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED  
POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-20893

CONSISTENT THEORY OF NONLINEAR OPTICAL EFFECTS IN  
BOUNDED LIGHT BEAMS BY EXTENDING PARABOLIC  
EQUATIONS TO NONLINEAR PROBLEMS A66-24888

NONLINEAR OPTICS - LASERS, RAMAN SCATTERING,  
AND OPTICAL RESONATORS  
JPRS-29459 N65-21141

AKSELRAD, A.  
ROOM TEMPERATURE OPERATION OF PULSED GALLIUM  
ARSENIDE INJECTION LASER, AND IMPROVEMENT OF  
LASER DIODE STRUCTURE  
ECOM-01501-1 N66-20809

ALDAG, H. R.  
POWER OUTPUT AND THRESHOLD POWER FOR CONTINUOUS

- WAVE NEODYMIUM-CALCIUM TUNGSTATE LASER IN RANGE OF DRY ICE TO ROOM TEMPERATURE A65-22619
- ALEKSANDROV, A. P.**  
DEGREE OF EXCITATION OF METASTABLE STATE DETERMINED, USING LUMINESCENCE SATURATION PHENOMENON, CALCULATING POPULATION OF WORKING LEVEL OF LASER SUBSTANCE A66-22027
- ALFEEV, V. N.**  
MASER APPLICATIONS AS RADIO RECEIVERS, DISCUSSING MULTIRESONATOR ALL-PASS QUANTUM AMPLIFIERS A65-16282
- MASER APPLICATIONS AS RADIO RECEIVERS, DISCUSSING MULTIRESONATOR ALL-PASS QUANTUM AMPLIFIERS A65-25785
- ALLAN, D. W.**  
STATISTICAL ANALYSIS OF NOISE QUALITY OF ATOMIC FREQUENCY STANDARDS INCLUDING MASERS A66-24130
- ALLEN, C.**  
DEVELOPMENT AND APPLICATION OF IMPROVED MASER TECHNIQUES FOR BROADBAND MASER SYSTEM - TRAVELING WAVE MASER TECHNIQUES RADC-TR-65-148 N65-32203
- ALLEN, J. W.**  
PUMP POWER DEPENDENCE OF RUBY LASER STARTING AND STOPPING TIME PREDICTED VIA RATE EQUATION ANALYSIS A66-21309
- ALLEN, L.**  
DESIGN AND OPERATION OF HELIUM-NEON LASER NOTING RADIATION, FREQUENCY STRUCTURE, POWER DENSITY, EXTERNAL MAGNETIC FIELD EFFECT, APPLICATION, ETC A66-22980
- ALLEN, R. B.**  
COUPLED OPTICAL RESONATOR SYSTEM CHARACTERISTICS USING LASER RESONATORS COUPLED TO EXTERNAL RESONATORS N65-23492
- OPTICAL MASER OUTPUT POWER AFFECTED BY GAS MIXTURE AND PRESSURE, RESONATOR GEOMETRY, AND MIRROR REFLECTIVITY FOR PLASMA RESEARCH N65-23495
- POPULATION INVERSION AND OPTICAL MASER OSCILLATIONS IN MOLECULAR GASES N65-23497
- ALLEY, C. O.**  
RUBY LASER OPTICAL RADAR DETECTION OF UPPER ATMOSPHERIC BACKSCATTERING A66-24395
- AMBARTSUMIAN, R. V.**  
TIME PARAMETERS OF POWERFUL LASER MEASURED WITH GA AS PHOTODIODE, NOTING TIME CONSTANT AND TIME RESOLUTION OF PHOTODIODE A65-34552
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM, NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION A65-35877
- PROPAGATION RATE OF HIGH POWER LASER LIGHT PULSE IN INVERSELY POPULATED MEDIUM A66-15333
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM, NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION A66-18972
- NONLINEAR AMPLIFICATION OF LIGHT PULSE PASSING THROUGH LASER OPERATING AT SATURATION REGIME A66-21963
- AMMANN, E. O.**  
SOLID STATE MICROWAVE MASER ACTION AT 77.4 DEGREES K WITH BROADBANDING TECHNIQUE APPLIED TO INCREASE GAIN-BANDWIDTH PRODUCT, EXAMINING RUBY MATERIAL AND HIGH Q MICROWAVE CAVITIES A65-23155
- CARRIER FREQUENCY STABILIZATION OF FM LASER WITH RESPECT TO CENTER OF ATOMIC GAIN PROFILE, USING SMALL DISTORTION PRESENT IN LASER OSCILLATION A66-10966
- EXPERIMENTS ON HELIUM-NEON FM LASERS COVERING PHASE-LOCKED AND FM REGION POWER OUTPUT, MODULATION INDEX AND DISTORTION EXPERIMENTS A66-13955
- OPTICAL HETERODYNE DETECTION OF MICROWAVE MODULATED LIGHT USING TWO SEPARATE LASERS EDL-M779 N65-16777
- ANANEV, I. A.**  
STATIONARY AND TRANSIENT LIGHT AMPLIFICATION REGIMES IN ACTIVE MEDIA OPERATING ACCORDING TO FOUR-LEVEL SCHEME A65-18455
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM FLUORIDE DOPED WITH SAMARIUM A65-24085
- STATIONARY AND TRANSIENT LIGHT AMPLIFICATION REGIMES IN ACTIVE MEDIA OPERATING ACCORDING TO FOUR-LEVEL SCHEME A65-28084
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM FLUORIDE DOPED WITH SAMARIUM A65-34906
- SINGLE PULSE OPERATION OF LASERS, NOTING ENERGY STORAGE AND AMPLIFICATION EFFECT FOR FOUR- AND THREE-LEVEL ACTIVE MEDIUM A66-23667
- ANDERSON, J. E.**  
PULSED LASER WELDING, WIRE-TO-WIRE, SHEET-TO-SHEET, CIRCUIT BOARD, VACUUM TUBE, ETC A66-18153
- ANDERSON, L. K.**  
MICROWAVE AMPLIFICATION ACHIEVED IN SILICON DIODE EXHIBITING MICROPLASMA-FREE AVALANCHE MULTIPLICATION A65-19227
- DEVICES OBTAINING INFORMATION FROM MODULATED LASER BEAMS INCLUDING PHOTOEMISSIVE DETECTORS AND SOLID STATE PHOTODETECTORS A65-23964
- ANDERSON, W. W.**  
MODE GUIDING AND GAIN IN JUNCTION LASER DUE TO DIELECTRIC SANDWICH CONFINING WAVE PROPAGATION A66-13952
- ELECTRON BEAM PUMPED LASERS, DISCUSSING ENERGY DISSIPATION IN FAST ELECTRONS PASSING THROUGH CRYSTAL, LASER SEMICONDUCTOR CHARACTERISTICS, ETC A66-23433
- ANDO, T.**  
TRAVELING-WAVE TUBE WITH PHOTOELECTRIC CATHODE USED AS DEMODULATOR FOR LASER COMMUNICATION A65-14345
- ANDREEVA, T. L.**  
GAS LASER OUTPUT AND THRESHOLD IN POPULATION INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE AND FLUORO IODO METHYLIDYNE A66-16771
- ANDRESEN, H. G.**  
OPTICAL PATH LENGTH CHANGE MEASURED THROUGH LASER RODS WITHIN PUMPING PERIOD BY INTERFEROMETRIC TECHNIQUE A66-11376
- ARMS, F.**  
HELIUM-NEON LASER PREAMPLIFIER SYSTEM FOR VERY HIGH GAIN TRANSITION AT 3.39 MICRON WAVELENGTH A65-21335
- ARMS, F. R.**  
LOW NOISE KA-BAND TRAVELING WAVE MASER AMPLIFIER FOR WINDOW AT 8 MM WHERE ATMOSPHERIC ATTENUATION IS LOW A65-16565
- ARDITI, M.**  
THRESHOLD CONDITIONS FOR CONTINUOUS SELF-SUSTAINED OSCILLATIONS PRODUCED BY REGENERATIVE RUBIDIUM GAS MASER A65-17659
- ARECCHI, F. T.**  
PARAMETRIC DEPENDENCE OF TIME PROFILE, PEAK POWER AND NUMBER OF GIANT PULSES OF ROTATING PRISM C-SWITCHED LASERS A65-15103



- INTERFERENCE FRINGE VISIBILITY UP TO 120 M OPTICAL PATH DIFFERENCE, USING HELIUM-NEON LASER SOURCE  
A65-16766
- INTERACTION BETWEEN OPTICAL MASER MEDIUM AND ELECTROMAGNETIC PULSE PROPAGATING IN IT, DISCUSSING AMPLIFIER EQUATIONS AND STEADY STATE PULSE / SSP / IN AND OUT OF RESONANCE  
A65-33374
- ARMSTRONG, J. A.  
INTENSITY FLUCTUATIONS MEASURED IN EMISSION FROM VARIOUS LASING AND NONLASING MODES OF CONTINUOUS WAVE GA AS LASER  
A65-34687
- ASHBURN, E. V.  
BIBLIOGRAPHY OF OPEN LITERATURE ON LASERS, PART V  
A66-22876
- BIBLIOGRAPHY ON LASERS  
LR-18863  
N65-28545
- ASHBY, D. E. T. F.  
FREQUENCY RESPONSE AND CROSS COUPLING OF RED AND IR GAS LASER INTERFEROMETER FOR MEASURING PLASMA ELECTRON DENSITY  
A65-15819
- ASKARIAN, G. A.  
FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK SHOCK WAVE IN LASER BEAM  
A66-10263
- FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK SHOCK WAVE IN LASER BEAM  
A66-13308
- ATTARD, A. E.  
DEVELOPMENT OF SEMICONDUCTOR LIGHT SOURCES WITH RUBY LASERS AND ZINC-DOPED GA AS JUNCTION DIODES  
REPT.-6400-42-T  
N66-12450
- ATWOOD, J. G.  
OPTICAL AND LASER THRESHOLD MEASUREMENTS ON 39 FLAME-FUSION RUBIES TO OBTAIN HIGHEST OPTICAL QUALITY LASER RODS  
A65-16402
- ELECTRO-OPTICS CONTRIBUTIONS TO OPTICAL ASTRONOMY, IMAGE TRANSDUCERS, AND LASER RESEARCH AND EFFECT ON CIVILIAN TECHNOLOGY  
N66-17721
- AVEN, M.  
SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION, CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION, FREQUENCY MODULATION LASERS, AND GALLIUM COMPOUND INGOTS FOR LASER APPLICATION  
AFCL-64-1007  
N65-23135
- AVIZONIS, P. V.  
EXCITATION OF RUBY LASERS USING DOUBLE-PUMPED HIGH-INTENSITY HELICAL FLASH TUBES, OBTAINING TIME-RESOLVED SPECTRA OF ELECTRICAL DISCHARGES AND PLASMA TEMPERATURES  
A66-11446
- INTERNAL BUBBLE FORMATION AND CRACKING IN RODS OF Q-SWITCHED RUBY AND ND-GLASS LASERS CAUSED BY LASER LIGHT, AND IN CASE OF ND-GLASS RODS, BY PLATINUM INCLUSIONS IN GLASS  
A66-13002
- AYER, J. A.  
CURRENT-VOLTAGE CHARACTERISTICS OF CW X-BAND GA AS MICROWAVE GUNN GENERATOR  
A66-23029
- B**
- BACKLUND, P.  
REPLICA TECHNIQUES AND ELECTRON AND OPTICAL MICROSCOPY TO STUDY LASER IRRADIATED METAL SURFACES  
A66-18393
- BAERTSCH, R.  
SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION, CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION, FREQUENCY MODULATION LASERS, AND GALLIUM COMPOUND INGOTS FOR LASER APPLICATION  
AFCL-64-1007  
N65-23135
- FREQUENCY MODULATION LASER WITH COMPOSITE AXIAL
- MODES  
N65-23138
- BAGAEV, S. M.  
SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING  
A65-31306
- SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING  
A65-33352
- BAGLEY, A. S.  
HYDROGEN MASER AND CESIUM BEAM TUBE FREQUENCY STANDARDS COMPARED  
A65-16680
- COMPACT SOLID STATE CESIUM LASER BEAM FREQUENCY STANDARD FOR PRECISION CLOCKS  
N65-26681
- BAIBORODIN, I. V.  
EFFECTS OF RESONATOR LENGTH AND MIRROR TRANSPARENCY AND ALIGNMENT UPON DYNAMIC AND STATIC CHARACTERISTICS OF RUBY LASER WITH MODULATED Q-FACTOR  
A65-35786
- BAIRD, K. M.  
SIMPLE SINGLE MODE HELIUM-NEON LASER WHOSE OUTPUT IS SUFFICIENT FOR INTERFEROMETRIC METROLOGY  
A65-22621
- ELECTRODELESS EXCITATION OF DISCHARGE IN HELIUM-NEON GAS LASER TUBE APPLIED TO VOICE TRANSMISSION  
A66-14924
- BAKER, C. E.  
REAL TIME, PROJECTION DISPLAY SYSTEM USING LASER LIGHT SOURCE  
UI-903600-1  
N65-35989
- BAKER, D. A.  
PLASMA INTERFEROMETRY TECHNIQUE WHERE REFLECTED-BACK OUTPUT OF GAS LASER IS MODULATED, USING PHASE VARIATIONS  
A65-19754
- BAKUMENKO, V. L.  
LASER OSCILLATION IN CALCIUM TUNGSTATE CRYSTALS ACTIVATED WITH TRIVALENT PRASEODYMIUM  
A66-14898
- BALDWIN, G. C.  
REVIEW OF NONLINER PHENOMENA RELATIVE TO RESEARCH WITH INTENSE LIGHT SOURCES - LASERS  
REPT.-656L94  
N66-11935
- BALDWIN, G. D.  
PHOTOGRAPHIC FILM USED FOR QUANTITATIVE MEASUREMENTS OF INTENSITY DISTRIBUTION IN Q-SWITCHED LASER BEAM  
A66-14920
- THERMAL OPTICAL DISTORTION MEASUREMENTS FOR NEODYMIUM DOPED GLASS LASER ROD  
MDE-6236  
N66-22419
- BALSHOV, I. F.  
SINGLE PULSE OPERATION OF LASERS, NOTING ENERGY STORAGE AND AMPLIFICATION EFFECT FOR FOUR- AND THREE-LEVEL ACTIVE MEDIUM  
A66-23667
- BARBER, J. B.  
INTERFEROMETER USING SMALL DIFFRACTION GRATING AND GAS LASER LIGHT SOURCE IN SCHLIEREN SYSTEM FOR FLUID MECHANICS RESEARCH  
A65-25332
- BARCHEWITZ, P.  
CARBON MONOXIDE AND DIOXIDE VIBRATIONALLY INDUCED IR EMISSION WITH POSSIBLE APPLICATIONS TO CONTINUOUS LASER EMISSION  
A65-22463
- CONTINUOUS GAS LASER BY DIRECT HF EXCITATION OF NITROUS OXIDE AND MIXTURE WITH ARGON IN CAVITY, NOTING PERFORMANCES  
A65-23273
- CONTINUOUS LASER EMISSION DUE TO VIBRATIONAL TRANSITIONS IN CARBON DIOXIDE AND NITROUS OXIDE MIXTURES EXCITED BY HF SOURCE  
A65-26292
- LINEAR COEFFICIENT OF AMPLIFICATION OF CARBON DIOXIDE SUBJECTED TO HF EXCITATION FIELD FOR LASER EMISSION  
A66-12003

- BARKER, W. A.**  
DATA ON LASER MATERIALS REFERENCED TO MAY 1964  
INCLUDING LASER EMISSION LINES AND LASER  
PERFORMANCE PARAMETERS A65-22616
- BARKHODAROVA, T. M.**  
SPATIAL DISTRIBUTION OF ELECTRICAL FIELD OBTAINED  
BY FOCUSING RADIATION OF RUBY LASER A66-10250
- BARNES, F. S.**  
LASER RADIATION EFFECT ON VERTEBRATE EMBRYOS  
N65-16624
- BAROCCHI, F.**  
PEAK POWER TRANSIENTS OF NEAR CONFOCAL HELIUM-NEON  
LASER WORKING AT 6328 ANGSTROMS ON PULSED  
DISCHARGE BASIS A66-10329
- BARONE, S. R.**  
PERTURBED AND PLANE PARALLEL FABRY-PEROT  
RESONATORS, THERMAL FIELDS, QUANTUM OPTICAL  
COHERENCE, SPONTANEOUS EMISSION, AND DYNAMICAL  
THEORY OF LASER OSCILLATION A66-10329  
AFCL-65-270 N65-27088
- BARREKETTE, E. S.**  
LASER DEFLECTION AND SCANNING BY MEANS OF  
MULTIMODE CAVITIES WITH DYNAMIC SPATIAL FILTERS  
A66-14829
- BARTELL, L. S.**  
STIMULATED COMPTON SCATTERING OF ELECTRONS BY  
LASER BEAM  
IS-1187 N66-20388
- BARTOLI, U. A.**  
MULTICHANNEL PHOTOELECTRIC SPECTRUM ANALYZER WITH  
KERR CELL GATING RECORDS SPECTRUM OF LASER LIGHT  
SCATTERED FROM SINGLE GIANT PULSE IN PLASMA  
A65-28203
- BARYNIN, V. A.**  
GAS DISCHARGE BY LASER PULSE, TAKING INTO ACCOUNT  
PHOTOIONIZATION DUE TO ELECTRON IMPACT  
A66-24887
- BASIL, I. T.**  
LASER BEAM DIVERGENCE AND ENERGY DISTRIBUTION  
MEASUREMENT, USING WIDE LATITUDE FILM AND THIN  
CELLULOID MIRROR A65-17432
- PHOTOGRAPHIC FILM USED FOR QUANTITATIVE  
MEASUREMENTS OF INTENSITY DISTRIBUTION IN Q-  
SWITCHED LASER BEAM A66-14920
- BASOV, N. G.**  
OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER  
BY P-N TRANSITIONS TO INCREASE POWER AND  
DIRECTIVITY OF EMISSION A65-17319
- LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO  
DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF  
SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS  
A65-24879
- TIME DEPENDENCE OF LASER OPERATION MODES USING  
LASER MODEL WITH TWO OSCILLATION TYPES  
A65-27772
- SYNCHRONIZED MODE OF EXCITATION FOR DIFFRACTION-  
COUPLED LASER A65-28538
- OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER  
BY P-N TRANSITIONS TO INCREASE POWER AND  
DIRECTIVITY OF EMISSION A65-30372
- EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER  
WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF  
FORBIDDEN BAND IN GALLIUM ARSENIDE  
A65-31307
- EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER  
WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF  
FORBIDDEN BAND IN GALLIUM ARSENIDE  
A65-33354
- TIME PARAMETERS OF POWERFUL LASER MEASURED WITH  
GA AS PHOTODIODE, NOTING TIME CONSTANT AND TIME
- RESOLUTION OF PHOTOCODE A65-34552
- SYNCHRONIZED GENERATION OF RADIATION BY ALL  
SEMICONDUCTOR ELEMENTS OF LASER SYSTEM WITH  
RADIATIVE MIRRORS CAUSED BY DIFFRACTION OF  
ELECTROMAGNETIC FIELD A65-35279
- INDUCED RADIATION IN GA AS SEMICONDUCTOR CRYSTAL  
EXCITED BY RUBY LASER WITH Q-MODULATION  
A65-35842
- LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION  
A65-35875
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A65-35877
- LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO  
DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF  
SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS  
A65-36356
- INDUCED RADIATION AND LASER ACTION OF GALLIUM  
ARSENIDE SINGLE CRYSTAL EXCITED BY LIGHT FROM  
Q-MODULATED RUBY LASER A65-36362
- ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION  
IN NEODYMIUM GLASS LASER A65-36826
- ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION  
INVERSION IN LEVELS OF OPTICAL TRANSITION  
A66-10448
- NONLINEAR INTERACTION OF OSCILLATIONS OF TWO TYPES  
IN LASER DOES NOT AFFECT STATIONARY OPERATION WHEN  
OSCILLATIONS ARE SUFFICIENTLY APART IN BAND  
A66-10724
- SYNCHRONIZED MODE OF EXCITATION FOR DIFFRACTION-  
COUPLED LASER A66-12293
- ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION  
INVERSION IN LEVELS OF OPTICAL TRANSITION  
A66-13311
- ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION  
IN NEODYMIUM GLASS LASER A66-13431
- OPTICALLY CONNECTED LASER CONSTRUCTED ON GALLIUM  
ARSENIDE P-N JUNCTION, NOTING COHERENT RADIATION  
A66-14363
- GALLIUM ARSENIDE P-N JUNCTION LASER DIODE COVERING  
INJECTION CURRENT DISTRIBUTION, DENSITY AND  
EMISSION SPECTRA VARIATION A66-14659
- PROPAGATION RATE OF HIGH POWER LASER LIGHT PULSE  
IN INVERSELY POPULATED MEDIUM A66-15333
- TIME DEPENDENCE OF LASER OPERATION MODES, USING  
LASER MODEL WITH TWO OSCILLATION TYPES  
A66-16626
- EXCITATION OF SEMICONDUCTOR LASERS BY BEAM OF FAST  
ELECTRONS, DISCUSSING WORK OF SHOCKLEY, POPOV,  
KELDYSH AND KROKHIN A66-17337
- LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION  
A66-18970
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A66-18972
- GENERATION IN CADMIUM SULFIDE DURING TWO-PHOTON  
OPTICAL EXCITATION BY RUBY LASER WITH MODULATED  
Q-FACTOR A66-19620
- NONLINEAR AMPLIFICATION OF LIGHT PULSE PASSING  
THROUGH LASER OPERATING AT SATURATION REGIME  
A66-21963
- GALLIUM ARSENIDE LASER EXCITATION BY FAST  
ELECTRONS A66-22146
- GENERATION OF LIGHT USING SEMICONDUCTOR QUANTUM  
GENERATORS - SOLID STATE LASERS  
FTD-TT-65-337/184 N65-32851

- CONDITIONS FOR EXISTENCE OF RADIATING MIRROR LASER  
ATD-T-65-47 N65-35043
- MASER DEVELOPMENT FROM INVERSIONAL TRANSITIONS IN  
HEAVY AMMONIA BEAM  
FTD-MT-64-330 N65-36869
- SPECTRAL ANALYSIS OF OUTPUT FROM SINGLE CRYSTAL  
SEMICONDUCTOR GENERATOR EXCITED BY ELECTRON  
BEAM - LASERS  
FTD-TT-65-555/16264 N66-12624
- BASS, J. C.  
TRANSVERSE ELECTRON-BEAM WAVE EXCITATION BY  
PHOTOELECTRIC MIXING OF LASER BEAMS  
A65-32874
- BASS, M.  
STIMULATED EMISSION FROM CHROMIUM IONS IN Q-  
SPOILED RUBY LASER A65-35066
- OPTICAL RECTIFICATION IN CRYSTALS USING RUBY  
LASER BEAM  
TID-21807 N65-35445
- BATULEV, V. M.  
SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION  
PROPERTY CHANGES DUE TO PULSED RUBY LASER  
RADIATION A66-20895
- BAUGH, C. W.  
CATHODOLUMINESCENT PHOSPHORS AS LIGHT SOURCE FOR  
LASERS, REDUCING HEAT LIMITATIONS AND ELIMINATING  
INTERNAL STRESSES CAUSED BY THERMAL GRADIENTS  
A65-30436
- OPTICAL LASER PUMPS, HIGH POWER CW LASER  
OPERATION BY CATHODOLUMINESCENCE AND SUITABLE  
SELECTION OF PHOSPHORS A66-19546
- BAYBORODIN, YU. V.  
RADIATION PULSES FROM RUBY OPTICAL QUANTUM  
GENERATOR DURING SINGLE IGNITION  
FTD-TT-65-134/162 N65-33409
- BAYLEY, D. S.  
METASTABLE NITROGEN MOLECULES AS ACTIVE MEDIUM  
FOR TRANSFORMER LASER PUMPED BY BATTERY OF NO  
GLASS AUXILIARY LASERS  
GPL-A-31-2 N66-17001
- BAZHULIN, P. A.  
LASER PULSE GENERATION WITH PLASMA RESULTING FROM  
DISCHARGE IN HYDROGEN AS MEDIUM  
A65-22728
- BAZZILL, C. H.  
PLANAR, CONFOCAL, AND SOLID STATE LASERS  
N65-25126
- BECKER, C. H.  
COHERENT LIGHT RECORDING AND REPRODUCING SYSTEM  
COMPRISING TWO-DIMENSIONAL QUANTUM MECHANICAL  
DATA PROCESS OF ULTIMATE PACKING DENSITY AND  
FREQUENCY BANDWIDTH  
RADC-TR-65-130 N65-35528
- BECKER, G.  
SEPARATION AND FOCUSING OF ATOMIC BEAMS FOR ATOMIC  
HYDROGEN MASERS N65-26679
- BECKMANN, P.  
COHERENT LASER BEAM USED TO SHOW CONSTANCY OF  
VELOCITY OF ELECTROMAGNETIC RADIATION  
A65-14215
- STATISTICAL DISTRIBUTION OF ARRIVAL ANGLE, SPOT  
LOCATION, AMPLITUDE, ETC., OF LASER BEAM TRAVERSING  
TURBULENT ATMOSPHERE A65-24931
- BEEKRODE, R.  
CHEMICAL LASER WITH INPUT ENERGY DERIVED SOLELY  
FROM CHEMICAL REACTION PRODUCED RADIATION, NOTING  
PROCESS OF COHERENT LIGHT PRODUCTION  
A65-20001
- BEGUN, M. A.  
AMMONIA MASER - AMMONIA MOLECULAR GENERATOR  
FTD-TT-65-803/16264 N66-19855
- BEHRINGER, R. E.  
LASER PHYSICS CONFERENCE - ENERGY EXCHANGE IN  
SOLIDS AND GASES, NONLINEAR EFFECTS, GAS  
BREAKDOWN, AND REFRACTIVE INDEX VARIATION  
AD-622507 N66-14573
- BEKEFI, G.  
LASER INTERFEROMETER TO MEASURE TIME AND SPATIAL  
VARIATION IN REPETITIVELY PULSED PLASMA  
A66-10243
- BELENOV, E. M.  
OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER  
BY P-N TRANSITIONS TO INCREASE POWER AND  
DIRECTIVITY OF EMISSION A65-17319
- LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO  
DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF  
SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS  
A65-24879
- PLASMA KINETIC PROCESSES IN NE- HE LASER LEADING  
TO POPULATION INVERSION A65-27738
- SYNCHRONIZED MODE OF EXCITATION FOR DIFFRACTION-  
COUPLED LASER A65-28538
- OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER  
BY P-N TRANSITIONS TO INCREASE POWER AND  
DIRECTIVITY OF EMISSION A65-30372
- PLASMA KINETIC PROCESSES IN NE- HE LASER LEADING  
TO POPULATION INVERSION A65-31843
- SYNCHRONIZED GENERATION OF RADIATION BY ALL  
SEMICONDUCTOR ELEMENTS OF LASER SYSTEM WITH  
RADIATIVE MIRRORS CAUSED BY DIFFRACTION OF  
ELECTROMAGNETIC FIELD A65-35279
- LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO  
DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF  
SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS  
A65-36356
- SHARPLY DIRECTIONAL COHERENT RADIATION GENERATION  
BY SYNCHRONIZED LASERS OR MULTIMIRRORED RESONATOR  
OF SINGLE LASER A66-11007
- SYNCHRONIZED MODE OF EXCITATION FOR DIFFRACTION-  
COUPLED LASER A66-12293
- SHARPLY DIRECTIONAL COHERENT RADIATION GENERATION  
BY SYNCHRONIZED LASERS OR MULTIMIRRORED RESONATOR  
OF SINGLE LASER A66-19945
- MASER WITH TWO SERIES RESONATORS  
N65-13904
- BELIAMIN, V. A.  
TREATMENT OF STEEL WITH LASER BEAM, OBTAINING  
PRECISION HOLES WITHOUT AFFECTING MICROHARDNESS OF  
METAL A66-24898
- BELIKOVA, T. P.  
DESTRUCTIVE AND LUMINESCENCE EFFECTS OF FOCUSED  
RUBY LASER BEAM ON RUBY A66-10265
- DESTRUCTIVE AND LUMINESCENCE EFFECTS OF FOCUSED  
RUBY LASER BEAM ON RUBY A66-13310
- BELL, M. E.  
PLASMA RING DISCHARGE EXCITATION USED TO DRIVE  
HIGH CURRENT DENSITY ELECTRODELESS ARC FOR  
EXCITING GAS ION LASER TRANSITIONS  
A66-10967
- ISOTOPE SHIFT, LINEWIDTH AND PRECISE WAVELENGTH OF  
LASER EMISSION IN IONIZED HG A66-18035
- BELOUSOVA, I. M.  
ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS  
LASER WITH PLANE PARALLEL MIRRORS  
A65-15458
- ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS  
LASER WITH PLANE PARALLEL MIRRORS  
A65-28554

**BENEDEK, G.**

BRILLOUIN SCATTERING IN LIQUIDS EXAMINING  
VELOCITY, FREQUENCY AND LIFETIME OF THERMALLY  
EXCITED HYPERSONIC SOUND WAVES, USING LASER LIGHT  
SOURCES A66-12422

**BENNETT, W. R., JR.**

RECENT DEVELOPMENTS IN GAS LASERS WITH ATTENTION  
TO INVERSION MECHANISMS, TWO AND THREE LEVEL  
COLLISION LASERS, ION LASERS AND CURRENTLY KNOWN  
TRANSITIONS A65-20060

MEASUREMENT OF GAS LASER RADIATIVE DECAY RATES AND  
TOTAL INELASTIC DESTRUCTIVE CROSS SECTION OF SHORT  
LIVED EXCITED STATES IN 4-NSEC TO 1000-NSEC RANGE  
A65-20061

COLLISION AND POWER BROADENING EFFECTS IN TUNED-  
LASER ABSORPTION SPECTROSCOPY, USING TIME  
DEPENDENT PERTURBATION THEORY A65-20065

EXCITATION AND INVERSION METHOD IN GAS LASERS  
NOTING CHARACTERISTICS OF HELIUM-NEON LASER AND  
IONIZED AND THREE-LEVEL LASER SYSTEM A66-13951

LASER ACTION ON FIVE GREEN LINES AND SIX IR LINES  
CAUSED BY PULSED MANGANESE DISCHARGE OF COLLISION  
LASER IN ATOMIC VAPOR OF NEUTRAL MANGANESE  
A66-16763

**BENZ, K.-W.**

GALLIUM ARSENIDE INJECTION LASER FOR PROLONGED  
OPERATION AT LIQUID NITROGEN TEMPERATURES  
A66-10369

**BERG, H. C.**

HYDROGEN MASER CONSTRUCTION AND OPERATION DESIGN  
PRINCIPLES EMPHASIZING MICROWAVE CAVITY, LOW  
MAGNETIC FIELD, HYDROGEN STORAGE AND MASER TUNING  
TECHNIQUES A65-24309

**BERGER, W. E. E.**

ELECTRODELESS EXCITATION OF DISCHARGE IN HELIUM-  
NEON GAS LASER TUBE APPLIED TO VOICE TRANSMISSION  
A66-14924

**BERGMAN, T. G.**

LASER RANGEFINDERS  
NOTS-TP-3539 N65-16822

LASER RANGEFINDER DESIGN - LASER RADAR COMPARISON,  
WAVELENGTH DEPENDENCE AND CONSIDERATIONS FOR  
DETECTION, COMPONENTS, BACKGROUND AND DETECTOR  
NOISE, OUTPUT ATTENUATION, AND RIFLE RANGEFINDER  
NAVWEP-8674 N65-22879

**BERGMANN, S. M.**

THEORY OF INDUCED AND SPONTANEOUS LASER EMISSION  
FROM ATOMIC LEVEL SYSTEM AND INCIDENT BEAMS OF  
RADIATION  
AFRL-65-505 N66-11992

**BERGQUIST, T.**

LASER IRRADIANCE LEVELS FOR RETINAL LESIONS  
A66-80011

**BERKLEY, D. A.**

SILICON CONTROL RECTIFIER LONG PULSE DRIVER FOR  
INJECTION LASERS A65-30330

**BERNAL, G., E.**

INTERACTION MECHANISM BETWEEN LASER BEAM AND  
SURFACE IN ULTRAHIGH VACUUM A66-15484

**BERNSTEIN, I. B.**

INTERACTION OF ENERGETIC ELECTRONS WITH BOUNDED  
ELECTROMAGNETIC WAVES NEAR CYCLOTRON RESONANCE,  
NOTING PLASMA DIAGNOSTICS, MASER AND GAIN  
MECHANISM A66-13953

**BERSHTEIN, I. L.**

LOCK-ON BAND OF CONTINUOUSLY OPERATING LASER  
OSCILLATOR DETERMINED FOR TRAVELING WAVE CIRCUIT  
A65-30070

PHASE RELATIONS OF LONGITUDINAL MODES IN GAS LASER  
WITH ANNULAR RESONATOR A66-10726

LOCK-ON BAND OF CONTINUOUSLY OPERATING LASER  
OSCILLATOR DETERMINED FOR TRAVELING WAVE CIRCUIT  
A66-17623

**BERTHELOT, J.**

LASER BEAM USE IN BIOLOGY AND MEDICINE, NOTING  
INTERACTION OF ELECTROMAGNETIC RADIATION WITH  
BIOLOGICAL SYSTEMS, HAZARDS, DIAGNOSTICS,  
THERAPEUTICS, ETC A66-14455

**BERTOLOTI, M.**

COHERENCE PROPERTIES OF HELIUM-NEON LASER WITH  
SUPERIMPOSED MODES EXAMINED BY INTERFERENCE  
PATTERN A66-10337

**BESPALOV, V. I.**

AUTOMODULATION OF EMISSION FROM SOLID STATE LASER  
A65-24809

PERIODIC AUTOMODULATION OF RADIATION AND  
POSSIBILITY OF GENERATING GIANT PULSES IN THREE-  
LEVEL LASER WITH INHOMOGENEOUSLY EXCITED ACTIVE  
MEDIUM A66-11842

STATISTICAL CHARACTERISTICS OF AUTOMODULATION OF  
SOLID LASER RADIATION N65-27234

**BESSHAPOSHNIKOV, A. A.**

MEASURING DEVICE FOR PULSED LASER OUTPUT POWER  
USING BOLOMETER, AMPLIFIER AND OSCILLOSCOPE  
A66-13888

**BESSON, J.**

STIMULATED EMISSION IN INDIUM ARSENIDE SHOWS  
EXCITATION THRESHOLD LOW AND LIGHT EMISSION HIGHLY  
DIRECTIONAL A66-17026

**BESSON, J. M.**

PRESSURE DEPENDENCE OF DOMINANT EMISSION MODES  
FROM Pb Se DIODE LASER A66-13003

**BETTINGER, R. T.**

RUBY LASER OPTICAL RADAR DETECTION OF UPPER  
ATMOSPHERIC BACKSCATTERING A66-24395

**BEVOLO, A. J.**

DATA ON LASER MATERIALS REFERENCED TO MAY 1964  
INCLUDING LASER EMISSION LINES AND LASER  
PERFORMANCE PARAMETERS A65-22616

**BHAUMIK, M. L.**

OPTICAL PUMPING ENERGY TRANSFER MECHANISM IN RARE  
EARTH CHELATES NOTING POSSIBILITY AS LASER  
MATERIAL A65-20075

LASER SURVEILLANCE USING OPTICAL BEAM SCANNING FOR  
DETECTION OF SPACE SATELLITES AND BALLISTIC  
MISSILES  
RADC-TOR-63-557 N65-22210

MATERIAL TESTING FOR GAS LASER OSCILLATOR AND  
SOLID STATE CHELATE LASER - OPTICAL RADARS  
RADC-TR-64-526 N66-12838

**BICKART, C. J.**

OPTICAL PATH LENGTH CHANGE MEASURED THROUGH LASER  
RODS WITHIN PUMPING PERIOD BY INTERFEROMETRIC  
TECHNIQUE A66-11376

**BICKNELL, W. E.**

LASER EXCITATION IN QUARTZ OF ELASTIC MODES OF  
THICK PLATE, SUGGESTING ENERGY COUPLING MECHANISMS  
A66-12423

**BIERSTEDT, P. E.**

GADOLINIUM MOLYBDENATE AS FERROELECTRIC HOST IN  
PULSED LASER, NOTING LIGHT MODULATION AND CRYSTAL  
DOMAIN A66-23207

**BIRBECK, F. E.**

OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER  
AS AIRCRAFT ALTIMETER TO ELIMINATE SPURIOUS ECHOES  
A65-32588

DESIGN OF COMPACT 100 WATT GALLIUM ARSENIDE LASER  
TRANSMITTER N65-20177

OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER  
AS TRANSMITTER AND SILICON P-I-N PHOTODIODE AS

- DETECTOR USED AS AIRCRAFT ALTIMETER  
N66-11665
- BIRKS, L. S.  
RUBY LASER CRYSTALS GROWN BY FLAME-FUSION, FLUX  
AND CZOCHRALSKI METHOD EXAMINED FOR PERFECTION BY  
X-RAY TOPOGRAPHY AND DOUBLE-CRYSTAL ROCKING  
CURVES  
A66-13744
- BIRKY, M. M.  
DISPERSION OF 1.15 MICRON HE- NE LASER LINE  
RESULTING FROM NEON ABSORPTION TRANSITION  
A65-31762
- BIRNBAUM, M.  
RUBY LASER POWER DEPENDENCE ON FREQUENCY SPLITTING  
OF TWO COMPONENTS OF R1 DOUBLET AT 77 DEGREES K  
A65-17654
- PARALLEL GROOVES AS SURFACE DAMAGE IN  
SEMICONDUCTORS PRODUCED BY RUBY LASER AS  
DIFFRACTION EFFECT  
A66-13753
- MODULATION OF REFLECTIVITY OF SEMICONDUCTORS  
ILLUMINATED BY INTENSE LASER BEAMS  
SSD-TDR-64-253  
N65-16566
- BISPLINGHOFF, R. L.  
NASA PROGRAM OF ADVANCED SPACE RESEARCH AND  
TECHNOLOGY - PLANETARY EXPLORATION, ENERGY  
CONVERSION, MATERIALS SCIENCE, AND LASERS  
N66-12404
- BISS, R. E.  
ELECTRON AND ION EMISSION FROM PULSED RUBY LASER  
ILLUMINATED METALLIC SURFACE INTO VACUUM,  
DETERMINING APPLICATION TO PULSED ION THRUSTOR  
AIAA PAPER 66-230  
A66-21453
- BJORKHOLM, J. E.  
OPTICAL SECOND HARMONIC GENERATION IN FOCUS OF  
LOWEST TRANSVERSE MODE OF CONTINUOUS WAVE  
GAUSSIAN GAS LASER BEAM  
A66-21175
- BLASZCZAK, Z.  
POLISH-MADE HE- NE RED GAS LASERS, DESCRIBING  
POWER OUTPUTS, GAS PRESSURE, HE/ NE RATIO,  
MIRROR TRANSMISSION COEFFICIENT AND  
INTERFEROMETRIC APPLICATION  
A66-23946
- BLECHERT, G.  
LASER BEAM MODULATION METHODS ASSESSED FOR MAKING  
USE OF CAPABILITY OF LASER FOR CARRYING MULTITUDE  
OF SIGNALS SIMULTANEOUSLY  
A66-11692
- BLEEKRODE, R.  
CHEMICAL LASER PRINCIPLE CONSIDERING POPULATION  
INVERSIONS FROM CHEMICAL REACTION  
A65-20002
- FLAME EMISSION DATA AND ABSORPTION CHARACTERISTICS  
SUITABLE FOR POPULATION INVERSION FOR LASER  
ACTION, NOTING LOW PRESSURE OXYACETYLENE FLAME  
A65-20070
- BLOEMBERGEN, N.  
LASER BEAM MULTIMODE EFFECTS AS HINDRANCE TO  
INTERPRETATION OF QUANTITATIVE MEASUREMENTS OF  
RAMAN GAIN  
A65-26958
- BLOOM, A. L.  
NOISE IN GAS LASERS AND LASER DETECTORS,  
AMPLIFIERS AND OSCILLATORS, NOTING HELIUM-NEON  
LASER OSCILLATION  
A65-31002
- ISOTOPE SHIFT, LINEWIDTH AND PRECISE WAVELENGTH OF  
LASER EMISSION IN IONIZED HG  
A66-18035
- HIGH POWER MERCURY LASER OPERATIONS IN KRYPTON AND  
ARGON AS FUNCTION OF MAGNETIC FIELD  
QPR-2  
N65-22323
- SPECTROSCOPY OF HIGH POWER GAS LASER EMISSION  
IN VISIBLE SPECTRUM FROM CW ARGON, KRYPTON,  
XENON, AND MERCURY-HELIUM LASERS  
QPR-3  
N65-31202
- BOCEK, V.  
RUBY-LASER ROD HOMOGENEITY DETERMINATION BY  
INTERFEROMETERS  
A65-19569
- BOGDANKEVICH, O. V.  
LOCAL LASER HEATING OF CATHODE FOR ELECTRON  
EXTRACTION FROM PLASMOID  
A66-16149
- EXCITATION OF SEMICONDUCTOR LASERS BY BEAM OF FAST  
ELECTRONS, DISCUSSING WORK OF SHOCKLEY, POPOV,  
KELDYSH AND KROKHIN  
A66-17337
- GALLIUM ARSENIDE LASER EXCITATION BY FAST  
ELECTRONS  
A66-22146
- SPECTRAL ANALYSIS OF OUTPUT FROM SINGLE CRYSTAL  
SEMICONDUCTOR GENERATOR EXCITED BY ELECTRON  
BEAM - LASERS  
FTD-TT-65-555/16264  
N66-12624
- BOIKO, V. A.  
HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A65-35877
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A66-18972
- BOILEAU, E.  
STATISTICAL MODEL OF RANDOM QUASI-SINUSOIDAL  
FUNCTION OF CONSTANT AMPLITUDE REPRESENTED BY  
EMISSION OF LASER OR RADIO TRANSMITTER  
A66-18637
- BOIVIN, A.  
INTEGRAL REPRESENTATION FOR ELECTROMAGNETIC FIELD  
IN FOCAL REGION OF COHERENT LIGHT BEAM EMERGING  
FROM APPLANATIC OPTICAL SYSTEM  
A65-27092
- BOKUT, B. V.  
LIGHT WAVE FREQUENCY CONVERSION BY LASER CRYSTAL,  
EXAMINING RESULTANT HARMONICS  
A65-15508
- BOLWIJN, P. T.  
INTERFEROMETER TUNING EFFECT ON ZEEMAN BEAT  
FREQUENCY IN RADIATION OF HELIUM-NEON LASER WITH  
APPLIED MAGNETIC FIELD  
A65-26956
- BONDAREV, B. I.  
INDUCED RADIATION AT HIGH PHOTON DENSITIES, NOTING  
APPLICABILITY OF PERTURBATION THEORY TO  
MULTIPHOTON RESONANCE RADIATION OF LASERS  
A66-20344
- BONIFACIO, R.  
INTERACTION BETWEEN OPTICAL MASER MEDIUM AND  
ELECTROMAGNETIC PULSE PROPAGATING IN IT,  
DISCUSSING AMPLIFIER EQUATIONS AND STEADY STATE  
PULSE / SSP/ IN AND OUT OF RESONANCE  
A65-33374
- BOOHER, J.  
EFFECT OF RUBY LASER ENERGY ON GAMMA RADIATED  
HUMAN ADENOCARCINOMA CELLS  
SAM-TR-65-41  
N66-11874
- BOORNARD, A.  
MEASUREMENT OF ELECTRON DENSITY OF GAS DISCHARGE  
PLASMA BY LASER INTERFEROMETER  
A66-16379
- BOOT, H. A. H.  
MICROMACHINING WITH PULSED HELIUM-NEON GAS LASER,  
NOTING EXPERIMENTAL TECHNIQUES, OPERATION AND  
APPLICATION  
A66-19734
- BORCHARDT, H. J.  
GADOLINIUM MOLYBDENATE AS FERROELECTRIC HOST IN  
PULSED LASER, NOTING LIGHT MODULATION AND CRYSTAL  
DOMAIN  
A66-23207
- BORODULIN, V. I.  
COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM  
OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE  
FABRY- PEROT RESONATOR  
A65-24088
- COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM  
OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE  
FABRY- PEROT RESONATORS  
A65-34909

- BORRELLI, N. F.**  
RADIAL DEPENDENCE OF ABSORBED ENERGY DISTRIBUTION  
IN CYLINDRICAL ROD OF NEODYMIUM GLASS PUMPED WITH  
XENON SOURCE A65-29792
- SPECTRAL PUMPING EFFICIENCY, SOLARIZATION EFFECT,  
ENERGY OUTPUT, SPECTROSCOPY, GLASS DAMAGE AND  
OPTICAL PATH DISTORTIONS IN NEODYMIUM GLASS  
LASERS  
AD-612964 N65-24195
- EFFECTS OF INTENSE ULTRAVIOLET RADIATION ON GLASS  
MATERIALS, AND PERFORMANCE CHARACTERISTICS OF  
GLASS LASERS  
AD-623309 N66-14533
- BORTFELD, D. P.**  
GAIN MEASUREMENTS OF RAMAN AMPLIFIER PUMPED BY  
DIFFUSE RUBY RADIATION A66-16388
- BOWEN, D. B.**  
GAS LASER OSCILLATOR AND SOLID STATE CHELATE LASER  
RADC-TDR-64-442 N65-16013
- BOWERS, B. C.**  
OPTICAL COMMUNICATION IN SPACE USING LASERS,  
EMPHASIZING NATURAL LIMITATIONS, E.G., ATMOSPHERIC  
ABSORPTION A65-21077
- BOWMAN, C. E.**  
GASEOUS AND RUBY LASERS AS LIGHT SOURCES FOR  
PHOTOELASTICITY  
TEAM-276 N65-29794
- BOWNESS, C.**  
RELATIVE EFFICIENCIES OF SINGLE AND MULTIPLE  
ELLIPTICAL CAVITIES FOR LASER PUMPING PRESENTED IN  
GRAPHICAL FORM A65-16401
- BOYD, G. D.**  
VELOCITY MATCHED SECOND HARMONIC GENERATION / SHG/  
AND MIXING OBTAINED IN PIEZOELECTRIC LITHIUM  
NIOBATE CRYSTALS A65-19235
- BOYDEN, J. H.**  
SOLID STATE LASER AMPLIFIER STRUCTURES  
QPR-8 N66-12048
- BOYNE, H. S.**  
DISPERSION OF 1.15 MICRON HE- NE LASER LINE  
RESULTING FROM NEON ABSORPTION TRANSITION A65-31762
- BRADFORD, J. N.**  
MAGNIFICATION OF SMALL RAY DEVIATIONS CAUSED BY  
REFRACTIVE INHOMOGENEITIES IN LARGE RUBY RODS  
WITH BREWSTER-ANGLE ENDS A66-12217
- LASER RESEARCH DEALING WITH EFFECT OF PUMPING ON  
RUBY QUALITY, LANTHANUM FLUORIDE EXAMINATION,  
LARGE RUBY LASER RODS, DC OPERATION OF MERCURY  
TUBE, HOLOGRAMS, AND LASER PHYSICS  
NRL-MR-1604 N65-28920
- BRADLEY, J.**  
MEASUREMENT OF VERTICAL WATER VAPOR PROFILES BY  
MEANS OF THERMALLY TUNED RUBY LASER OPTICAL  
RADAR SYSTEM - HUMIDITY MEASUREMENT  
REPT.-65-6 N66-14852
- BRAND, F. A.**  
RUBY LASER AMPLIFIER AT LIQUID-NITROGEN  
TEMPERATURE TREATED AS THREE-MEDIUM TRANSMISSION  
SYSTEM, NOTING GAIN CHANGE WITH NEGATIVE  
ATTENUATION A66-22867
- MULTIPLE REFLECTION THEORY APPLIED TO REGENERATIVE  
LASER AMPLIFIER DESIGN  
ECOM-2531 N65-19166
- REGENERATIVE RUBY LASER AMPLIFIERS AT LIQUID  
NITROGEN TEMPERATURES  
ECOM-2575 N65-35642
- BRANDLE, C. D.**  
GROWTH OF HIGH OPTICAL QUALITY LANTHANUM-ALUMINUM  
OXIDE SINGLE CRYSTAL BY CZOCHRALSKI METHOD -  
DEFENDER PROJECT  
SRCR-65-4 N65-34084
- BRANIGAN, T. L.**  
LECTURE MANUSCRIPTS ON HIGH ALTITUDE EXPLOSIONS,  
BIOLOGICAL EXPLORATION OF MARS, MASERS AND  
LASERS, PLANETARY ATMOSPHERES, RELATIVITY  
THEORY, ELEMENT ABUNDANCE, AND SOLAR PARTICLES  
N65-31360
- BRANNEN, E.**  
REFLECTION GRATINGS AS END PLATES IN FABRY-  
PEROT CAVITY, WITH CHARACTERISTICS OF LOW  
ABSORPTION OUTPUT COUPLING AND WAVELENGTH-  
DEPENDENT ALIGNMENT OF END PLATES A66-19930
- BRAULT, J. W.**  
EMISSION AND ABSORPTION PROFILES FOR RUBY R SUB 1  
LINES SHOW ABSENCE OF SIGNIFICANT STOKES SHIFT  
A65-17664
- BRAUNSTEIN, R.**  
DOUBLE PHOTON ABSORPTION, HARMONIC GENERATION,  
AND FREQUENCY MIXING IN SEMICONDUCTORS, AND  
FREQUENCY TUNING OF INJECTION LASERS BY  
UNIAXIAL STRESS  
AD-450756 N65-14437
- BRAY, W. J.**  
FACILITIES AND EQUIPMENT AT GOONHILLY DOWNS  
SATELLITE SYSTEM GROUND STATION - STEERABLE  
ANTENNA, COMPUTING AND DATA TRANSMISSION, AND  
HELIUM SYSTEM FOR MASER INSTALLATION N66-10260
- BRECHER, C.**  
LASER ACTION IN RARE EARTH CHELATES, EMPHASIZING  
CHEMISTRY AND SPECTROSCOPIC PROPERTIES OF  
MATERIALS AND PROPERTIES OF LIQUID LASER A65-20074
- EMISSION SPECTRA OF TRIS AND TETRAKIS FORMS OF  
FOUR BETA-DIKETONE EUROPIUM CHELATES STUDIED FOR  
LIQUID LASER APPLICATION A65-33308
- CHELATE LASER SYSTEMS - EUROPIUM BENZOYLACETONATE  
TR-64-052.7 N65-14405
- RARE EARTH CHELATE LASERS N65-15508
- EMISSION SPECTROSCOPY AND COORDINATION CHEMISTRY  
OF EUROPIUM CHELATE SOLUTIONS - CHELATE LASERS  
INVESTIGATED FOR EVALUATING POTENTIALITIES OF  
LIQUID LASERS  
TR-65-052-11 N66-14177
- COORDINATION AND CHEMICAL EQUILIBRIUM IN CHELATE  
LASER MATERIALS N66-20730
- BRET, G.**  
RAMAN DIFFUSION OF LIQUIDS PLACED OUTSIDE OPTICAL  
CAVITY AND EXCITED BY RUBY LASER A65-27944
- BRETON, C.**  
LASER BEAM-GAS INTERACTION INDUCED DISCHARGE  
STUDIED FOR THRESHOLD, BREAKDOWN AND EMITTED LIGHT  
CHARACTERISTICS A65-27084
- INTENSE LASER BEAM FOCUSING EFFECT IN GAS TO  
STUDY LIGHT-INDUCED DISCHARGES BY TIME-RESOLVED  
SPECTROSCOPY AND PHOTOGRAPHY A66-12978
- BRIDGES, T. J.**  
CRYSTALLINE CALCITE USED AS DICHROIC POLARIZER IN  
IR REGIONS, LASER RADIATION, ZEEMAN EFFECT AND  
NOISE PROPERTIES MEASUREMENTS, ETC A65-33419
- HIGH POWER BREWSTER WINDOW LASER WITH GAS FILLS,  
DISCUSSING POWER OUTPUT AND EFFICIENCY PARAMETERS  
A66-13983
- TRAVELING WAVE OSCILLATIONS OF ION RING LASER IN  
MIRROR-RING RESONATOR A66-14903
- OUTPUT SPECTRA OF ARGON ION LASER IN RING  
RESONATOR AND TWO MIRROR RESONATORS A66-14904

- BRIDGES, W. B.**  
VISIBLE AND UV LASER OSCILLATION AT 118  
WAVELENGTHS IN IONIZED NEON, ARGON, KRYPTON,  
XENON, OXYGEN AND OTHER GASES A65-22622
- LASER OSCILLATION IN GASEOUS IONS, TABULATION OF  
WAVELENGTHS, CLASSIFICATIONS AND REFERENCES FOR  
230 ION LASER TRANSITIONS A65-30343
- BRILL, G. A., JR.**  
ADAPTABILITY OF LASERS TO SCHLIEREN SYSTEMS -  
PHOTOGRAPHIC LIGHTING SYSTEMS  
ARL-65-139 N66-14801
- BRIONES, R. A.**  
HIGH SPEED PHENOMENA HOLOGRAMS PRODUCED BY  
RADIATION FROM PULSED RUBY LASER OPERATED EITHER  
IN Q-SWITCHED OR CONVENTIONAL MODE A65-35067
- BROCK, E. G.**  
LASER MODULATION AT ATOMIC LEVEL - POPULATION  
INVERSION AND ESTIMATE OF ZEEMAN SPLITTING  
NASA-CR-60572 N65-16320
- RUBY LASER MODULATION AT ATOMIC LEVEL - FREQUENCY  
SHIFT MEASUREMENT OF LASER EMISSION UNDER  
INHOMOGENEOUS MAGNETIC FIELD BY SPECTROSCOPY  
NASA-CR-57464 N65-19863
- LASER MODULATION AT ATOMIC LEVEL - YTTRIUM-  
ALUMINUM GARNET EMISSION AND LASER EMISSION  
SHIFT WITH HOMOGENEOUS PULSED MAGNETIC FIELD  
NASA-CR-57823 N65-21308
- MEASUREMENT OF TEMPERATURE DEPENDENCE OF ENERGY  
LEVELS INVOLVED IN LASER EMISSION  
NASA-CR-64436 N65-32191
- BRODIN, M. S.**  
SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION  
PROPERTY CHANGES DUE TO PULSED RUBY LASER  
RADIATION A66-15354
- SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION  
PROPERTY CHANGES DUE TO PULSED RUBY LASER  
RADIATION A66-20895
- BRODA, H. P.**  
LASER OSCILLATION IN DECAY OF EXCITED MOLECULES  
FROM CHEMICAL REACTION, NOTING CHANGE IN THREE  
ELECTRONIC LEVELS IN MOLECULAR SYSTEM A65-20069
- LASER TRANSITION IN VIBRATIONAL STATE OF GROUND  
ELECTRONIC STATE OF CN FROM ROTATIONAL LEVEL 8 TO  
7 WITH POPULATION INVERSION AS RESULT A66-11451
- BROOKE, P.**  
ELECTROSTATIC IMAGE CONVERTER CAMERA USED IN  
PLASMA AND LASER RESEARCH FOR HIGH SPEED WRITING  
A65-32585
- BROOKS, R. E.**  
HIGH SPEED PHENOMENA HOLOGRAMS PRODUCED BY  
RADIATION FROM PULSED RUBY LASER OPERATED EITHER  
IN Q-SWITCHED OR CONVENTIONAL MODE A65-35067
- BROOM, R. F.**  
COMPACT PULSE GENERATOR FOR DRIVING GALLIUM  
ARSENIDE LASERS AT ROOM TEMPERATURE N65-20175
- METHOD FOR PRODUCING COMPACT BEAM FROM ARRAY OF  
LASERS N65-20176
- BROPHY, V. A.**  
RARE EARTH CHELATE LASERS N65-15508
- BROSSEL, J.**  
QUANTUM THEORY OF OPTICAL PUMPING CYCLE DEVELOPED  
FROM ANALYSIS OF EFFECTS OF LIGHT ON ATOMIC ENERGY  
LEVELS A65-24003
- BROUDE, V. L.**  
RADIATION FLUCTUATIONS IN LASER PULSE REGIME,  
DISCUSSING ERRORS ARISING IN COMPARING BASIC WITH  
SECONDARY EMISSION A65-14617
- TIME CHARACTERISTICS IN GENERATION OF GIANT LASER  
PULSE STUDIED BY CIRCUIT WITH PRISMATIC SHUTTERS  
A66-13889
- DISPERSION RESONATOR PERFORMANCE IN RUBY LASER,  
SHOWING GENERATION OF R SUB 1 AND R SUB 2 LINES  
A66-16346
- THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-19669
- THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-21836
- DISPERSION RESONATOR PERFORMANCE IN RUBY LASER,  
SHOWING GENERATION OF R SUB 1 AND R SUB 2 LINES  
A66-22345
- RADIATION PULSES FROM RUBY OPTICAL QUANTUM  
GENERATOR DURING SINGLE IGNITION  
FD-65-134/162 N65-33409
- BROWN, E. B.**  
BOOK ON MODERN OPTICS INCLUDING LASER AND COHERENT  
LIGHT, GEOMETRICAL OPTICS, LENS SYSTEMS,  
INSTRUMENTS, ETC A66-12623
- BROWN, F.**  
SECOND HARMONIC LIGHT GENERATED ON REFLECTION OF  
GIANT-PULSE LASER BEAM FROM SURFACE OF SILVER  
MIRROR A66-16072
- BROWN, W. P., JR.**  
DISPERSION EFFECTS IN LASER AMPLIFIERS  
AFOSR-65-2211 N66-16411
- BROWNE, P. F.**  
GAS BREAKDOWN BY LASER CAN BE ACCOUNTED FOR BY  
BOTH MICROWAVE BREAKDOWN THEORY AND INVERSE  
BREMSSTRAHLUNG A66-17040
- MATERIAL VAPORIZATION BY Q-SPOILED LASER PULSES  
FOR SPECTROSCOPIC ANALYSIS OF VAPOR OPTICAL  
EMISSION AND ABSORPTION PROPERTIES  
AFRL-64-871 N65-22274
- BRUCE, C. W.**  
INSTRUMENTATION SYSTEM FOR MEASUREMENT OF PULSED  
LASER OUTPUT - CALORIMETER AND INTEGRATOR  
WL-TR-64-127 N65-34706
- BRUNA, M.**  
EVAPORATED CADMIUM SULFIDE THIN FILMS PROCESSED TO  
ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING  
LASER-INDUCED ELASTIC VIBRATION A65-31942
- BRUNA, M. S.**  
PROCESSING EVAPORATED CADMIUM SULFIDE THIN FILMS  
TO ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING  
LASER-INDUCED ELASTIC VIBRATIONS A65-21875
- BRUNET, H.**  
TWO BREWSTER-TYPE LASERS IN OSCILLATOR-AMPLIFIER  
CONFIGURATION USED TO MEASURE LASER GAIN IN  
XENON-KRYPTON DISCHARGE A65-34610
- BRYANT, J. F.**  
CUT-OFF OF RUBY LASER EMISSION BY PULSED ELECTRON  
AND BREMSSTRAHLUNG RADIATION, USING ADIABATIC  
TEMPERATURE A66-12447
- BUCZEK, C. J.**  
SPONTANEOUS EMISSION FROM ATOM INTERACTING WITH  
COHERENT LIGHT WAVE  
AFOSR-65-1000 N66-12043
- BULLMINKEL, E. C.**  
DATA PULSED TRANSMISSION OVER ELECTRON-INJECTION  
LASER COMMUNICATION SYSTEM, USING CONTINUOUS WAVES  
A66-19934
- BUNKIN, F. B.**  
MULTIPHOTON ABSORPTION IN LASER GA AS AND RUBY

- CRYSTAL OF OPTICAL GENERATOR A65-26025
- BUNKIN, F. V.**  
MULTIPHONON ABSORPTION IN LASER GA AS AND RUBY  
CRYSTAL OF OPTICAL GENERATOR A66-11727
- BURBECK, R. N.**  
ELECTROSTATIC IMAGE CONVERTER CAMERA USED IN  
PLASMA AND LASER RESEARCH FOR HIGH SPEED WRITING  
A65-32585
- BURCH, D. E.**  
ABSORPTION OF 3.39 MICRON HELIUM-NEON LASER  
EMISSION BY METHANE IN ATMOSPHERE  
A65-16362
- BURCH, J. M.**  
LASER APPLICATIONS IN PRECISION AND HIGH SPEED  
MEASUREMENT AND APPLICATION IN PHOTOGRAPHY, LONG  
DISTANCE METROLOGY AND PLASMA DIAGNOSTICS  
A65-20003
- BURGESS, T. J.**  
EFFECT OF HIGH VELOCITY TRANSLATION ON PHOTON  
CORRELATIONS IN LASER INTERFEROMETERS  
UCRL-14345 N66-10969
- BURGHARD, G. M.**  
WAVEGUIDE COUPLING BETWEEN ADJACENT PARALLEL  
FIBERS AS MEANS OF TRANSFERRING RADIATION FROM  
ONE ELEMENT TO ANOTHER A66-14827
- BURIAKIVS-KII, G. IU.**  
MINIMUM VALUE OF TIME DEPENDENT LASER RADIATION  
LOSSES AT WHICH GIANT OSCILLATIONS OCCUR  
A65-19740
- BURIAKIVSKII, G. IU.**  
LASER EMISSION WITH VARIABLE RESONATOR LOSSES,  
CONSIDERING RELATIVELY LOW INITIAL OVERPOPULATION  
A65-35784
- KINETIC EQUATION OF LASER OPTIMUM EMISSION,  
DETERMINING PUMPING EFFICIENCY, VALUE OF LOSSES IN  
SPECIAL MODES, ETC A66-11058
- BURIAKOVSKII, G. IU.**  
KINETIC EQUATION THEORY APPLIED TO STEADY STATE  
LASER RADIATION DUE TO BAND-BAND TRANSITION IN  
SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS  
A65-26694
- KINETIC EQUATION THEORY APPLIED TO STEADY STATE  
LASER RADIATION DUE TO BAND-BAND TRANSITION IN  
SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS  
A65-32952
- BURKE, J. J., JR.**  
WAVEGUIDE COUPLING BETWEEN ADJACENT PARALLEL  
FIBERS AS MEANS OF TRANSFERRING RADIATION FROM  
ONE ELEMENT TO ANOTHER A66-14827
- BURKHALTER, J. H.**  
RUBY LASER FOR STUDY OF LASER RADIATION EFFECTS  
ON BIOLOGICAL ORGANISMS  
OR-3885 N66-10583
- BURLAMACCHI, P.**  
PEAK POWER TRANSIENTS OF NEAR CONFOCAL HELIUM-NEON  
LASER WORKING AT 6328 ANGSTROMS ON PULSED  
DISCHARGE BASIS A66-10329
- BURRELL, G. J.**  
SEMICONDUCTOR INJECTION LASERS AND LAMPS  
RAE-TR-65095 N65-36334
- BUSCHER, H. T.**  
BREAKDOWN OF ARGON BY NEODYMIUM AND RUBY LASER  
PULSES  
REPT.-1935-1 N65-22072
- BUSER, R. G.**  
PINCH METHODS OF GAS DISCHARGE AS LIGHT SOURCE FOR  
OPTICAL PUMPING OF VARIOUS LASER MATERIALS  
N65-22742
- BUSH, C. C.**  
CONVENTIONAL FLOW VISUALIZATION USING LASER LIGHT  
SOURCE
- AIAA PAPER 66-127 A66-17104
- BUSH, W. D.**  
AUTOMATIC FREQUENCY CONTROL OF LASER LOCAL  
OSCILLATOR FOR HETERODYNE DETECTION OF LASER  
SIGNAL AND USE OF 2.5 GC FREQUENCY OFFSET TO  
PERMIT RETRIEVAL OF MICROWAVE DATA A66-14908
- OPTICAL HETERODYNE DETECTION OF MICROWAVE  
MODULATED LIGHT USING TWO SEPARATE LASERS  
EDL-M779 N65-16777
- BUTLER, J. F.**  
PB SE DIODE LASER FABRICATION, PROPERTIES AND  
EMISSION SPECTRUM WITH PEAK AT 8.5 MICRONS  
A65-27602
- PRESSURE DEPENDENCE OF DOMINANT EMISSION MODES  
FROM PB SE DIODE LASER A66-13003
- BYER, R. L.**  
ISOTOPE SHIFT, LINEWIDTH AND PRECISE WAVELENGTH OF  
LASER EMISSION IN IONIZED HG A66-18035
- SPECTROSCOPY OF HIGH POWER GAS LASER EMISSION  
IN VISIBLE SPECTRUM FROM CW ARGON, KRYPTON,  
XENON, AND MERCURY-HELIUM LASERS  
QPR-3 N65-31202
- BYKOV, V. P.**  
THEORETICAL OPTICAL RESONATOR FOR LASER WITH RARE  
EARTH LIQUID SOLUTIONS AS ACTIVE COMPONENTS  
A66-21970
- BYRON, S.**  
SHOCK TUBE LASER PUMPING - FOUR COMBINATIONS  
OF LASER CRYSTAL AND PUMPING CONFIGURATION  
U-3104 N65-28154
- CHEMICAL PUMPING OF LASERS - EYE DAMAGE IN  
MONKEYS FROM LASER IRRADIATION  
U-3259 N66-13799
- C**
- CADDES, D.**  
COHERENT LIGHT DIFFRACTION BY MICROWAVE SOUND IN  
TRANSPARENT CRYSTALS A65-29265
- CADDES, D. E.**  
OPTICAL HETERODYNE DETECTION OF MICROWAVE  
MODULATED LIGHT USING TWO SEPARATE LASERS  
EDL-M779 N65-16777
- CALAWA, A. R.**  
PB SE DIODE LASER FABRICATION, PROPERTIES AND  
EMISSION SPECTRUM WITH PEAK AT 8.5 MICRONS  
A65-27602
- LASER ACTION AT LIQUID HELIUM TEMPERATURE IN  
CRYSTALS OF LEAD SAMARIUM, LEAD SELENIDE AND LEAD  
TELLURIDE EXCITED BY FAST ELECTRON BEAM  
A65-30346
- PRESSURE DEPENDENCE OF DOMINANT EMISSION MODES  
FROM PB SE DIODE LASER A66-13003
- CALDWELL, J. J., JR.**  
FAST HIGH RADIANCE ABLATING LASER PUMP AND ENERGY  
STORAGE TECHNIQUE  
AFAL-TR-65-22 N65-22702
- CALLEAR, A. B.**  
VIBRATIONAL, ELECTRONIC AND TRANSLATIONAL ENERGY  
TRANSFERS OF GAS MOLECULE COLLISIONS, NOTING  
QUENCHING PROCESS AND FREQUENCY DIFFERENCES  
EFFECT A65-20068
- CALVIELLO, J. A.**  
SIMULTANEOUS LASER OSCILLATION OBSERVED AT 6943  
AND 6929 ANGSTROM WAVELENGTHS IN NORMAL AND Q-  
SPOILED OPERATION OF RUBY LASER  
A65-32748
- CANIT, J.-C.**  
NONLINEAR OPTICS IN MICROSCOPIC SEARCH FOR ORIGIN  
AND MACROSCOPIC STUDY OF LINKING BETWEEN INCIDENT  
RADIATION AND INDUCED RADIATION



- A65-36219  
**CAPET, M.**  
 LASER BEAM-GAS INTERACTION INDUCED DISCHARGE  
 STUDIED FOR THRESHOLD, BREAKDOWN AND EMITTED LIGHT  
 CHARACTERISTICS A65-27084
- INTENSE LASER BEAM FOCUSING EFFECT IN GAS TO  
 STUDY LIGHT-INDUCED DISCHARGES BY TIME-RESOLVED  
 SPECTROSCOPY AND PHOTOGRAPHY A66-12978
- CARAS, G. J.**  
 FOUR-LEVEL, GAS, LIQUID, SEMICONDUCTOR, AND RUBY  
 LASERS  
 RSIC-195 N65-24836
- CARRINGTON, T.**  
 CHEMICAL PROCESSES PRODUCING SPECTROSCOPICALLY  
 OBSERVABLE POPULATION INVERSIONS IN ATOMIC OR  
 MOLECULAR LASERS A65-20066
- CARSWELL, A. I.**  
 OPTICAL RESONATOR EFFECTS ON POPULATION  
 DISTRIBUTION IN HELIUM-NEON GAS LASERS DETERMINED  
 FROM SIDE LIGHT MEASUREMENTS A65-21656
- CARTER, W. H.**  
 MAXWELL EQUATIONS AS MATHEMATICAL MODELS FOR  
 SOLUTION OF DIFFRACTION IMAGING THEORY OF  
 COHERENT MONOCHROMATIC LIGHT IN MICROSCOPY  
 N65-23494
- CARUSO, A.**  
 PLASMA PRODUCTION USING GIANT LASERS FOCUSED ON  
 SMALL SPECKS OF SOLID MATERIAL A65-30792
- CARVER, T. R.**  
 THRESHOLD CONDITIONS FOR CONTINUOUS SELF-SUSTAINED  
 OSCILLATIONS PRODUCED BY REGENERATIVE RUBIDIUM GAS  
 MASER A65-17659
- CASELIA, A. J.**  
 REGULAR PERIODIC SPIKING IN OUTPUT OF PULSED  
 NEODYMIUM DOPED BORATE GLASS LASER AT PUMPING  
 LEVELS SLIGHTLY ABOVE THRESHOLD A66-16672
- CASELLA, A. J.**  
 EFFECT OF LASER OPERATION PARAMETERS USING  
 NEODYMIUM DOPED BORATE GLASS ON THRESHOLD AND  
 OUTPUT ENERGY  
 R-1748 N65-25782
- LASER THEORY WITH CLASSICAL AND QUANTUM MECHANICAL  
 APPROACH TO ABSORPTION AND EMISSION  
 R-1743 N66-20857
- CASTRO, J.**  
 RUBY LASER AMPLIFIER AT LIQUID-NITROGEN  
 TEMPERATURE TREATED AS THREE-MEDIUM TRANSMISSION  
 SYSTEM, NOTING GAIN CHANGE WITH NEGATIVE  
 ATTENUATION A66-22867
- MULTIPLE REFLECTION THEORY APPLIED TO REGENERATIVE  
 LASER AMPLIFIER DESIGN  
 ECOM-2531 N65-19166
- REGENERATIVE RUBY LASER AMPLIFIERS AT LIQUID  
 NITROGEN TEMPERATURES  
 ECOM-2575 N65-35642
- CAULFIELD, H. J.**  
 TRANSMISSION THROUGH TAPERED QUARTZ TUBE IN LASER  
 NEAR FIELD A66-15481
- CAYMAN, G.**  
 LASER ACTION IN ALLOYED GALLIUM ARSENIDE JUNCTION  
 DIODE SUBMERGED IN LIQUID NITROGEN  
 A65-29198
- CESENA, R. A.**  
 CUT-OFF OF RUBY LASER EMISSION BY PULSED ELECTRON  
 AND BREMSSTRAHLUNG RADIATION, USING ADIABATIC  
 TEMPERATURE A66-12447
- CHAICA, M. P.**  
 INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY  
 AFTER LEAVING LASER AND AFTER FOCUSING WITHIN  
 LENS, NOTING OPTIMUM FOCUSING CONDITIONS
- A65-36050  
 INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY  
 AFTER LEAVING LASER AND AFTER FOCUSING WITHIN  
 LENS, NOTING OPTIMUM FOCUSING CONDITIONS  
 A66-15853
- CHAKRABORTY, D.**  
 GC/S NITROGEN-COOLED NONDEGENERATE PARAMETRIC  
 AMPLIFIER, NOTING DESIGN, APPLICATION AND  
 OPERATION CHARACTERISTICS A66-21857
- CHAKRAVARTI, A. N.**  
 EFFECTIVE MASS IN IN AS AND IN SB FROM LANDAU  
 SHIFT OF PEAK EMISSION IN LASER DIODES  
 A66-21579
- CHALMETON, V.**  
 LASER BEAM-GAS INTERACTION INDUCED DISCHARGE  
 STUDIED FOR THRESHOLD, BREAKDOWN AND EMITTED LIGHT  
 CHARACTERISTICS A65-27084
- INTENSE LASER BEAM FOCUSING EFFECT IN GAS TO  
 STUDY LIGHT-INDUCED DISCHARGES BY TIME-RESOLVED  
 SPECTROSCOPY AND PHOTOGRAPHY A66-12978
- CHAMBERLAIN, J. E.**  
 REFRACTIVE INDEX OF SOLID DETERMINED, USING FAR  
 IR MICHELSON INTERFEROMETER ILLUMINATED WITH  
 RADIATION FROM CN MASER A65-24683
- CHAMPETIER, J.-L.**  
 EVOLUTION OF LUMINOUS ZONE OF PLASMA GENERATED BY  
 FOCUSING LASER BEAM IN AIR A66-15097
- CHANG, D.**  
 MEASUREMENT OF VERTICAL WATER VAPOR PROFILES BY  
 MEANS OF THERMALLY TUNED RUBY LASER OPTICAL  
 RADAR SYSTEM - HUMIDITY MEASUREMENT  
 REPT.-65-6 N66-14852
- CHANG, G. K.**  
 MODULATION INDUCING RETRODIRECTING OPTICAL  
 SYSTEM - DIODE MOUNT FOR GALLIUM ARSENIDE  
 LASERS, AND GENERATION OF ALKALINE LINE BY  
 STIMULATED RAMAN EMISSION  
 NASA-CR-57922 N65-21342
- CHANG, W. S. C.**  
 COHERENCE THEORY FOR COLLIMATION AND FOCUSING OF  
 TIME-AVERAGED INTENSITY OF PULSED MULTIMODE LASER  
 RADIATION A66-12205
- CHARLES, R. G.**  
 ORGANIC CATIONS EFFECT ON LASER THRESHOLD OF  
 SOLUTIONS OF TETRAKIS FORM OF EUROPIUM  
 BENZOYLTRIFLUOROACETONATE A66-18418
- HEAVY WATER USED AS LIQUID LASER SOLVENT FOR HIGH  
 RADIANCE LIQUID LASER SYSTEMS AND RESEARCH IN  
 OUTPUT BEAM DIVERGENCE, SPECTRAL NARROWING, AND  
 THRESHOLDS FOR LASER ACTION  
 AD-610714 N65-27886
- CHARTERS, M. L.**  
 GLASS COMPOSITION EFFECT ON SPECTRAL PROPERTIES OF  
 ND-DOPED GLASSES AND SELECTING ONE FOR LASER  
 GLASS A65-17635
- RADIAL DEPENDENCE OF ABSORBED ENERGY DISTRIBUTION  
 IN CYLINDRICAL ROD OF NEODYMIUM GLASS PUMPED WITH  
 XENON SOURCE A65-29792
- CHARTIER, G.**  
 HIGH INTENSITY LOW VOLTAGE DISCHARGE RESULTING  
 FROM RUBY LASER BEAM FOCUSING ON TITANIUM HYDRIDE  
 TARGET A65-24282
- CHASTOV, A. A.**  
 RUBY LASER OUTPUT RADIATION CHANGE DUE TO  
 PHTHALOCYANINE SOLUTIONS PLACED IN RESONATOR  
 CAVITY A65-21071
- GIANT LASER EMISSION PULSES IN NEODYMIUM ACTIVATED  
 GLASS ROD BY VARYING CAVITY Q WITH QUINOLINE  
 SOLUTION OF POLYMETHINE DYE A65-27554
- RUBY LASER OUTPUT RADIATION CHANGE DUE TO  
 PHTHALOCYANINE SOLUTIONS PLACED IN RESONATOR

- CAVITY A65-31236
- CHATTERTON, E. J.  
SEMICONDUCTOR LASERS, FM TECHNIQUES AND MULTIPLE-  
SCATTER PATHS USED TO OVERCOME MODULATION NOISE  
UNDER VARYING WEATHER CONDITIONS A66-19915
- CHAU, M. N.  
INTERNAL MODULATION OF GAS LASER BY GERMANIUM  
PHOTODIODE INVERSELY POLARIZED AND MOUNTED IN  
COAXIAL CIRCUIT A65-16385
- CHEATHAM, E. M.  
OPTICAL FREQUENCY TRANSLATION TECHNIQUES LEADING  
TO DESIGN OF Y-SHAPED LASER CONFIGURATION  
A8-1272-0013 N65-15259
- CHEBOTAEV, V. P.  
GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM  
INCIDENT ON PLANE PARALLEL GLASS PLATE OF  
RESONATOR A65-18555
- OPTIMUM LASER EMISSION MODES RESULTING FROM HOLLOW  
CATHODE TUBE DISCHARGE DUE TO INELASTIC HELIUM  
NEON ATOM COLLISIONS A65-18556
- LASER OPERATION MODES ARISING FROM METASTABLE NEON  
ATOM ANNIHILATION BY HYDROGEN AND OXYGEN MOLECULES  
A65-18557
- VISUAL PERCEPTION OF INTENSE COHERENT IR  
RADIATION FROM GAS LASER A65-24083
- EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE  
OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE  
A65-24084
- HELIUM-NEON LASER OUTPUT DEPENDENCE ON HOLLOW  
CATHODE DISCHARGE CONDITIONS FOR ELECTRON  
TRANSITIONS IN NEON A65-25591
- GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM  
INCIDENT ON PLANE PARALLEL GLASS PLATE OF  
RESONATOR A65-27148
- OPTIMUM LASER EMISSION MODES RESULTING FROM HOLLOW  
CATHODE TUBE DISCHARGE DUE TO INELASTIC HELIUM  
NEON ATOM COLLISIONS A65-27149
- LASER OPERATION MODES ARISING FROM METASTABLE  
NEON ATOM ANNIHILATION BY HYDROGEN AND OXYGEN  
MOLECULES A65-27150
- VISUAL PERCEPTION OF INTENSE COHERENT IR  
RADIATION FROM GAS LASER A65-34904
- EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE  
OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE  
A65-34905
- RUBY CRYSTAL OPTICAL PROPERTIES INVESTIGATED BY  
INTERFERENCE RINGS FROM REFLECTING HE- NE LASER  
BEAM FROM CRYSTAL FACE A66-11045
- HELIUM-NEON LASER OUTPUT DEPENDENCE ON HOLLOW  
CATHODE DISCHARGE CONDITIONS FOR ELECTRON  
TRANSITIONS IN NEON A66-11422
- RUBY CRYSTAL OPTICAL PROPERTIES INVESTIGATED BY  
INTERFERENCE RINGS FROM REFLECTING HE- NE LASER  
BEAM FROM CRYSTAL FACE A66-23292
- CHEBOTAYEV, V. P.  
VISUAL PERCEPTION OF INFRARED LASER EMISSION  
NASA-TT-F-9888 N66-22300
- CHECCACCI, P. F.  
MICROWAVE MODELS USED TO MEASURE FREQUENCY AND  
QUALITY FACTORS OF FABRY-PEROT RESONATOR WITH  
PLANE SQUARE MIRRORS OPERATING IN X-BAND  
A66-14909
- MICROWAVE MODELS OF OPTICAL RESONATORS - LASER OR  
MICROWAVE RESONATOR WITH FLAT ROOF MIRRORS -  
OPEN LASER RESONATORS RESEARCH  
AFCL-65-568 N65-34155
- CHEN, C. J.  
IONIZATION PHENOMENA IN ARGON DUE TO LASER  
RADIATION BY MEASURING ELECTRON DENSITY AND ENERGY  
AS TIME FUNCTION AFTER LASER PULSE INITIATION AT  
DIFFERENT GAS PRESSURES AND PREIONIZED CONDITIONS  
AIAA PAPER 66-176 A66-21690
- CHEN, D.  
PULSED RUBY LASER RCD CAVITY LOSS MEASUREMENTS  
FROM 77 TO 293 DEGREES K INDICATING ESSENTIALLY  
CONSTANT LOSS A65-16129
- ZEEMAN EFFECT IN PARAMAGNETIC CRYSTALS BY RUBY FOR  
MICROWAVE MODULATION OF PULSED LASER BY ABSORPTION  
A65-32746
- CHENG, H.  
QUANTUM THEORY OF INTERACTION OF ELECTROMAGNETIC  
WAVES IN PLASMA CONSIDERED IN TERMS OF LIGHT-  
LIGHT SCATTERING AND PLASMA-LASER BEAM INTERACTION  
A66-21173
- CHEO, P. K.  
RESONANCE RADIATION TRAPPING BETWEEN LOWER LASER  
LEVEL AND ION GROUND STATE AS MECHANISM FOR  
QUENCHING AND RING-SHAPED BEAM FORMATION IN ION  
LASERS A65-26004
- U V ION LASER TRANSITIONS IN INERT GASES, OXYGEN  
AND NITROGEN BETWEEN 2300 AND 4000 ANGSTROMS,  
SHOWING RELATIONSHIP BETWEEN GAIN AND TUBE  
DIAMETER A65-27334
- U V AND VISIBLE LASER OSCILLATIONS IN FLUORINE,  
PHOSPHORUS AND CHLORINE ATOMS IN PULSED CHLORINE,  
PHOSPHORUS FLUORIDE AND SULFUR FLUORIDE GAS  
DISCHARGES A66-10972
- CHERKASOV, E. M.  
CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER A66-10704
- CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER A66-23309
- CHERNETS, A. N.  
MEASUREMENT OF RADIATION PATTERN OF RUBY LASER  
EMISSION FOR VARIOUS RESONATORS AND OPERATING  
REGIMES, NOTING LASER EFFECT ON ANGULAR HALF-WIDTH  
VALUES A66-22028
- CHERNOCH, J. P.  
GAIN DELAY CHARACTERISTICS OF FOUR-LEVEL  
NEODYMIUM-DOPED PULSED GLASS-LASER OSCILLATOR-  
POWER AMPLIFIER CHAIN A65-16574
- CHESTER, A. N.  
VISIBLE AND UV LASER OSCILLATION AT 118  
WAVELENGTHS IN IONIZED NEON, ARGON, KRYPTON,  
XENON, OXYGEN AND OTHER GASES A65-22622
- LASER OSCILLATION IN GASEOUS IONS, TABULATION OF  
WAVELENGTHS, CLASSIFICATIONS AND REFERENCES FOR  
230 ION LASER TRANSITIONS A65-30343
- CHETHIK, F.  
COHERENT LIGHT COMMUNICATION SYSTEM FOR ATMOSPHERE  
CONDITION EFFECTS ON FREQUENCY MODULATED LASER  
BEAM FR-66-14-37 N66-21774
- CHIANG, C.-H.  
TRANSMISSION CHARACTERISTICS OF NEODYMIUM LASER  
N66-16812
- CHIAO, R. Y.  
BRILLOUIN SCATTERING IN LIQUIDS EXCITED BY HE- NE  
MASER AND OBSERVED BY FABRY-PEROT  
INTERFEROMETER, NOTING ACOUSTIC WAVE VELOCITY AND  
LINE BROADENING A65-15699
- DYNAMICS AND CHARACTERISTICS OF SELF-TRAPPING OF  
INTENSE LIGHT BEAMS  
NASA-CR-74030 N66-23765
- CHILINGARIAN, IU. S.  
R SUB 1 RUBY LINE EMISSION AND FREQUENCY

- DEPENDENCE ON TEMPERATURE VARIATION  
A65-15205
- CHIPPAUX, C.  
RECOMBINATION RADIATION FROM GALLIUM ANTIMONIDE  
P-N JUNCTIONS, OBSERVING STIMULATED EMISSION AND  
LASER ACTION  
A65-30572
- CHIRINA, L. P.  
XENON-KRYPTON LASER EMISSION IN 12 WAVELENGTHS  
RANGING FROM 2.03 TO 9 MICRONS WITH EXTERNAL AND  
INNER MIRRORS  
A65-17353
- BEAM DIVERGENCE ANGLE OF SINGLE TEM MODE NE- HE  
LASER OUTPUT AT 0.63 MICRONS  
A65-27739
- BEAM DIVERGENCE ANGLE OF SINGLE TEM MODE NE- HE  
LASER OUTPUT AT 0.63 MICRONS  
A65-31844
- CHIZHIKOVA, Z. A.  
ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN  
ENERGY ABSORPTION AND POPULATION INVERSION  
A65-36055
- ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN  
ENERGY ABSORPTION AND POPULATION INVERSION  
A66-15858
- CHO, K. S.  
PARAMETER DEPENDENCE OF INTERMEDIATE FREQUENCY  
VOLTAGE INDICATED DURING ESTABLISHMENT OF OPTIMUM  
CONDITIONS FOR OPTICAL RECEIVERS AND MERIT OF  
SUBCARRIER MIXING  
A66-23960
- CHODOROW, M.  
MICROWAVE RESEARCH ON ACOUSTIC WAVE AMPLIFICATIONS  
AND GEOMETRICAL OPTICS, OPTICAL MASERS,  
ELECTRON-PHONON INTERACTIONS, AND RAMAN  
SCATTERING FROM BIREFRINGENT CRYSTALS  
ML-1277  
N65-20038
- ACOUSTIC WAVE AMPLIFICATION, OPTICAL MASER,  
TUNABLE LASER, GEOMETRICAL OPTICS, SEMICONDUCTOR  
OSCILLATION, AND SOLID STATE PLASMA STUDIES FOR  
MICROWAVE TRANSMISSION  
ML-1316  
N65-27969
- CHOLET, P. H.  
MODULATION INDUCING RETRODIRECTING OPTICAL  
SYSTEM - DIODE MOUNT FOR GALLIUM ARSENIDE  
LASERS, AND GENERATION OF ALKALINE LINE BY  
STIMULATED RAMAN EMISSION  
NASA-CR-57922  
N65-21342
- CHORAT, M.  
RELAXATION OSCILLATIONS IN FOUR-LEVEL SOLID STATE  
LASER STUDIED VIA DIFFERENTIAL EQUATIONS,  
CALCULATING SHAPE AND ENVELOPE OF OSCILLATION  
A65-30574
- CHOW, K. K.  
MICROWAVE BEATS IDENTIFIED BETWEEN MODES IN  
BROMINE-ARGON MIXTURE  
A66-14923
- CHU, T. S.  
HE- NE LASER IR RADIATION EMISSION ATTENUATED BY  
ATMOSPHERIC METHANE  
A66-23090
- CHURCH, C. H.  
EFFICIENT CONVERSION OF ELECTRICAL ENERGY INTO  
LASER RADIATION, USING COAXIAL OPTICAL PUMP  
A66-23479
- CIRINCIONE, P. A.  
BIOLOGICAL EFFECTS OF LASER RADIATION AND SAFETY  
RULES FOR PERSONNEL PROTECTION  
NAVTRADEVCEM-IH-15  
N65-14941
- CLARK, G. L.  
HIGH POWER LASER AMPLIFIER FOR OPTICAL RADAR  
TRANSMITTER - SPACE SURVEILLANCE SYSTEM  
EOS-5550-Q-1  
N66-12355
- CLARK, P. O.  
SELF-CONSISTENT FIELD ANALYSIS FOR FIELD  
DISTRIBUTIONS OF RESONANT MODES IN SPHERICAL  
MIRROR FABRY- PEROT RESONATOR  
A65-16566
- GAS PRESSURE AND TUBE DIAMETER EFFECT ON OPTICAL  
GAIN OPERATING CHARACTERISTICS OF XENON LASER  
AMPLIFIER  
A65-32743
- ELECTRON ENERGY SPECTRA IN GAS LASER DISCHARGES  
AND INVESTIGATION OF NEW DISCHARGE  
CONFIGURATIONS  
NASA-CR-67298  
N65-35355
- CLASS, W.  
ELECTRON BEAM AND HOLLOW CATHODE FLOAT-ZONE  
PROCESSES ANALYSIS FOR APPLICATION TO GROWTH OF  
LASER RUBY CRYSTALS  
AFCRL-65-908  
N66-21169
- CLAUSS, J.  
HIGH INTENSITY ULTRAVIOLET RADIATION SOURCE TO  
PUMP PHOSPHORS AND LASER MATERIALS WITH  
ABSORPTION BANDS IN PHOSPHOR EMISSION SPECTRUM  
DDRF-173  
N65-14365
- CLAUSS, R. C.  
TWO-CAVITY MASER AT 2388 MC FOR RADAR ASTRONOMY  
A65-29447
- CLAY, B. R.  
FABRICATION AND TEST OF CONTINUOUS WAVE LASER  
ACTION FROM DYSPROSIUM IN CALCIUM FLUORIDE EXCITED  
BY TUNGSTEN LAMP  
A65-19184
- CLEMESHA, B. R.  
LOWER ATMOSPHERIC DENSITY MEASUREMENTS THROUGH  
LIGHT SCATTERING FROM Q-SPOILED RUBY LASER BEAM,  
USING OPTICAL RADAR DETECTOR  
A66-20398
- CLOSE, D. H.  
NONLINEAR EFFECTS IN TRAVELING WAVE LASER  
AMPLIFIERS  
AFOSR-65-0999  
N66-10779
- CLUNIE, D. M.  
MICROMACHINING WITH PULSED HELIUM-NEON GAS LASER,  
NOTING EXPERIMENTAL TECHNIQUES, OPERATION AND  
APPLICATION  
A66-19734
- COCHRAN, G.  
COHERENT TRANSFER CHARACTERISTICS OF OPTICAL  
SYSTEM, HOLOGRAMS AND COMPLEX SPATIAL FILTERS,  
AND LASER APPLICATIONS  
D-5210-72-T80-110  
N65-21691
- COCHRAN, J. A.  
INTEGRAL EQUATIONS GOVERNING MODE SPECTRA OF  
LASER, INVESTIGATING EXISTENCE OF EIGENVALUES FOR  
HOLDER CONTINUOUS KERNELS  
A65-15806
- COLEMAN, P. D.  
OPTICAL PUMPING IN DARK RUBY, HARMONIC GENERATION  
IN HYDROGEN CYANIDE, SUBMILLIMETER WAVE  
SPECTROSCOPY, AND MIXING OF LASER LIGHT IN BULK  
PHOTOCONDUCTOR  
N65-26426
- COLLET, E. H.  
INSTRUMENTATION SYSTEM FOR MEASUREMENT OF PULSED  
LASER OUTPUT - CALORIMETER AND INTEGRATOR  
WL-TR-64-127  
N65-34706
- COLLINS, L. J.  
MIRROR HOLDER WITH DEFORMABLE HINGES GIVING  
CONSTANT HINGE LINES AT RIGHT ANGLES FOR GASEOUS  
AND SOLID STATE LASERS USE  
A65-28590
- COLLINS, R. J.  
MODE COMPETITION AND COUPLING IN Q-SWITCHED RUBY  
LASER  
A66-16383
- RUBY LASER FIELD PATTERNS - DIFFRACTION PATTERNS  
TR-1  
N65-22896
- THEORETICAL EXPLANATION FOR HIGHLY DIRECTIONAL  
OFF AXIAL RADIATION FROM SOLID STATE OPTICAL  
MASERS OF CIRCULAR CROSS SECTION  
TR-2  
N65-34713
- MICROWAVE FREQUENCY BEATS IN OFF-AXIS MODES OF  
RUBY LASERS  
TR-3  
N65-35553

- COLLINSON, J. A.**  
DESIGN AND CONSTRUCTION OF STABLE SINGLE FREQUENCY  
RF EXCITED HE- NE LASER AT 6328 ANGSTROMS  
A65-35358
- CROSS SECTION MEASUREMENT FOR ELECTROMAGNETIC  
BACKSCATTERING OF LASER BEAMS FROM ROUGH ALUMINUM  
AND MAGNESIUM OXIDE SURFACES  
A66-18930
- COLLIS, R. T. H.**  
LIGHT DETECTION AND RANGING / LIDAR/ TECHNIQUE USE  
IN ATMOSPHERIC RESEARCH, PARTICULARLY  
METEOROLOGICAL FACTORS IMPORTANT TO AVIATION AND  
ROCKET OPERATIONS  
AIAA PAPER 65-464  
A65-30204
- COLTMAN, J. W.**  
LASER OPERATION PRINCIPLES AND OSCILLATING ELEMENT  
OF LASER RESONATOR  
A65-31880
- COMPTON, D. M. J.**  
CUT-OFF OF RUBY LASER EMISSION BY PULSED ELECTRON  
AND BREMSSTRAHLUNG RADIATION, USING ADIABATIC  
TEMPERATURE  
A66-12447
- CONGER, R. L.**  
PHOTOTUBE OBSERVATION OF RUBY LASER OUTPUT  
AS FUNCTION OF TIME  
N65-15570
- CONRAD, H.**  
RUBY LASER CRYSTAL FLAWS OF CLOSELY PACKED  
SPHEROIDS SUGGESTING PLASTIC FLOW AND QUENCH-IN AS  
CAUSE  
A65-17684
- CONSOLI, T.**  
DENSITY, TEMPERATURE AND SPEED OF EXPANSION OF  
PLASMA CLOUD PRODUCED BY IMPACT OF RUBY LASER BEAM  
ON ALUMINUM STRIP  
A65-29558
- COOK, H. J.**  
GASEOUS AND SOLID LASER LINES SURVEY FOR LASER  
SPECTROSCOPY AND PLASMA DIAGNOSTICS  
NASA-CR-57334  
N65-19752
- COOKE, B. L.**  
LASER SURVEILLANCE USING OPTICAL BEAM SCANNING FOR  
DETECTION OF SPACE SATELLITES AND BALLISTIC  
MISSILES  
RADG-TDR-63-557  
N65-22210
- COOPER, H. G.**  
RESONANCE RADIATION TRAPPING BETWEEN LOWER LASER  
LEVEL AND ION GROUND STATE AS MECHANISM FOR  
QUENCHING AND RING-SHAPED BEAM FORMATION IN ION  
LASERS  
A65-26004
- U V ION LASER TRANSITIONS IN INERT GASES, OXYGEN  
AND NITROGEN BETWEEN 2300 AND 4000 ANGSTROMS,  
SHOWING RELATIONSHIP BETWEEN GAIN AND TUBE  
DIAMETER  
A65-27334
- U V AND VISIBLE LASER OSCILLATIONS IN FLUORINE,  
PHOSPHORUS AND CHLORINE ATOMS IN PULSED CHLORINE,  
PHOSPHORUS FLUORIDE AND SULFUR FLUORIDE GAS  
DISCHARGES  
A66-10972
- CORDOVER, R. H.**  
ISOTOPE SHIFT MEASUREMENT FOR 6328 ANGSTROMS  
HELIUM-NEON LASER TRANSITION  
A66-21070
- CORNEY, A.**  
INTENSITY OF POLARIZED LIGHT TRANSMITTED THROUGH  
LASER AMPLIFIER AND LINEAR POLARIZER, AS FUNCTION  
OF AXIAL MAGNETIC FIELD STRENGTH  
A66-17292
- CORMIN, R. R.**  
ENERGY LEVEL RELATIVE POPULATION DENSITIES OF NEON  
PLASMA USING HELIUM-NEON LASER - LANGMUIR PROBE  
ADDITIONS FOR MEASUREMENT OF PLASMA ELECTRON  
TEMPERATURE AND VELOCITY DISTRIBUTIONS  
ARL-65-246  
N66-22488
- COSDEN, T. H.**  
LOWER ATMOSPHERE ABSORPTION SPECTRUM STRUCTURE  
FROM 8512 TO 11600 Å - NEODYMIUM LASER SPECTRUM  
NRL-6352  
N66-17604
- COURTNEY-PRATT, J. S.**  
LIGHT OUTPUT FROM HELIUM-NEON GAS MASER  
PHOTOGRAPHED WITH AND WITHOUT INTRACAVITY  
MODULATION AT LOCKING FREQUENCY, USING HIGH SPEED  
ROTATING MIRROR  
A66-17205
- COURTOIS, N.**  
IMPROVEMENT OF FORECASTS AND ANALYSIS OF LASER  
MEASUREMENTS FOR SATELLITE S-66  
NASA-TT-F-8772  
N66-11607
- COWDER, L. R.**  
RUBY LASER PULSE TECHNIQUE APPLIED TO THERMAL  
DIFFUSIVITY MEASUREMENTS FOR TANTALUM AND  
GRAPHITE  
CONF-651020-1  
N66-18228
- COX, G.**  
HIGH INTENSITY ULTRAVIOLET RADIATION SOURCE TO  
PUMP PHOSPHORS AND LASER MATERIALS WITH  
ABSORPTION BANDS IN PHOSPHOR EMISSION SPECTRUM  
CDRF-173  
N65-14365
- CRAIG, J. P.**  
INFRARED MASER INTERFEROMETRY FOR TIME AND SPACE  
RESOLUTION OF ELECTRON DENSITY IN HIGH  
TEMPERATURE PLASMAS  
ARL-65-135  
N66-20024
- CRAMPTON, S. B.**  
HYDROGEN MASER CONSTRUCTION AND OPERATION DESIGN  
PRINCIPLES EMPHASIZING MICROWAVE CAVITY, LOW  
MAGNETIC FIELD, HYDROGEN STORAGE AND MASER TUNING  
TECHNIQUES  
A65-24309
- CROCKER, A.**  
LASER OSCILLATIONS FROM PULSED ELECTRICAL  
DISCHARGE THROUGH NITROUS OXIDE AT 10.9 MICRON  
WAVELENGTH  
N65-20172
- LASER OSCILLATIONS AT WAVELENGTHS BETWEEN 21 AND  
32 MICRONS FROM PULSED DISCHARGE THROUGH AMMONIA  
N65-20173
- CROME, K. R.**  
IMPROVED QUANTUM EFFICIENCY FROM LIGHT TRAPPED IN  
TRANSLUCENT PHOTOCATHODE LASER DETECTORS  
ITTIL-66-1002  
N66-20166
- CROWELL, M. H.**  
LASER OPERATION AS PULSED REGENERATIVE OSCILLATOR  
ARISING FROM MODE COUPLING DUE TO TIME-VARYING  
LOSS IN CAVITY OR NONLINEAR CHARACTERISTICS OF  
INVERTED POPULATION  
A65-27603
- CRUNLY, C. B.**  
LOCKING OF MODES IN HE- NE LASER AT 6328  
ANGSTROMS, USING EXTERNAL DOPPLER CELL  
A65-16668
- CULLOM, J. H.**  
LASER BEAM DIVERGENCE AND ENERGY DISTRIBUTION  
MEASUREMENT, USING WIDE LATITUDE FILM AND THIN  
CELLULOID MIRROR  
A65-17432
- PHOTOGRAPHIC FILM USED FOR QUANTITATIVE  
MEASUREMENTS OF INTENSITY DISTRIBUTION IN Q-  
SWITCHED LASER BEAM  
A66-14920
- THERMAL OPTICAL DISTORTION MEASUREMENTS FOR  
NEODYMIUM DOPED GLASS LASER ROD  
MDE-6236  
N66-22419
- CULSHAW, W.**  
BEAT FREQUENCIES AND COHERENCE PROPERTIES IN  
CIRCULARLY POLARIZED ATOMIC TRANSITIONS OF GASEOUS  
LASERS WITH AXIAL MAGNETIC FIELDS  
A66-18429
- BEAT FREQUENCY AND ROTATION OF POLARIZATION PLANE  
IN HE- NE LASER WITH AXIAL MAGNETIC FIELD  
A66-18430
- SIMULTANEOUS ACTION OF RF PERTURBATION BETWEEN  
ZEEMAN SUBLEVELS OF ATOMIC TRANSITION WHICH IS  
ALSO PRODUCING LASER OSCILLATION  
A66-21177
- PLANAR, CONFOCAL, AND SOLID STATE LASERS

- N65-25126
- CURCIO, J. A.  
COMPARISON OF UNDERWATER ATTENUATION OF RUBY  
LASER LIGHT WITH NONLASER LIGHT  
NRL-6181 N65-28158
- LOWER ATMOSPHERE ABSORPTION SPECTRUM STRUCTURE  
FROM 8512 TO 11600 Å - NEODYMIUM LASER SPECTRUM  
NRL-6352 N66-17604
- CURTIS, D. A.  
MAGNITUDE OF ANISOTROPIC LINE BROADENING IN RUBY  
A66-13278
- CUSANO, D. A.  
LASER EMISSION FROM N TYPE GALLIUM ARSENIDE  
CRYSTAL BY FAST ELECTRON EXCITATION, NOTING DOPING  
AND EMISSION ENERGY A65-19546
- LASER TRANSITION IDENTIFICATION IN ELECTRON BEAM  
PUMPED GALLIUM ARSENIDE, PRIMARILY ON  
CONCENTRATION OF SHALLOW DONORS AND ACCEPTORS  
A66-10348
- CUTLER, L. S.  
HYDROGEN MASER AND CESIUM BEAM TUBE FREQUENCY  
STANDARDS COMPARED A65-16680
- COMPACT SOLID STATE CESIUM LASER BEAM FREQUENCY  
STANDARD FOR PRECISION CLOCKS N65-26681
- CUTRONA, L.  
COHERENT TRANSFER CHARACTERISTICS OF OPTICAL  
SYSTEM, HOLOGRAMS AND COMPLEX SPATIAL FILTERS,  
AND LASER APPLICATIONS  
D-5210-72-T80-110 N65-21691
- CZARNIEWSKI, V.  
MODE LOCKING IN HELIUM-NEON LASER BY MEANS OF  
SYNCHRONOUS INTRACAVITY ACOUSTIC MODULATION IN  
COUPLED MULTIMODE CONFOCAL INTERFEROMETERS  
A65-24276
- CZERLINSKI, G.  
NANOSECOND HEATING OF AQUEOUS SYSTEMS BY  
Q-SWITCHING ROTATING PRISM RUBY LASER  
A65-15788
- LASER POWER DENSITY MEASURED WITH REDUCED  
ABSORPTION OF LIGHT BY METHYLENE BLUE, USING HE-  
NE- CW LASER A65-31455
- NANOSECOND HEATING OF AQUEOUS SYSTEMS BY GIANT  
LASER PULSES AND REDUCTION OF LIGHT ABSORPTION  
AT HIGH LASER POWER DENSITIES  
AD-451466 N65-16471
- D
- DAHLQUIST, J. A.  
NINE ADDITIONAL LASER LINES IN PULSED XENON  
DISCHARGE UNDER CONDITIONS THAT DO NOT PRODUCE  
PREVIOUSLY OBSERVED LINES A65-26953
- PLANAR, CONFOCAL, AND SOLID STATE LASERS  
N65-25126
- DAILEY, J. L.  
ROCKET MISSILE ATTITUDE SENSING DURING EARLY  
LAUNCH PHASE USING POLARIZED LASER BEAMS  
TRANSMITTED FROM GROUND STATION  
A65-23619
- DAINO, B.  
COHERENCE PROPERTIES OF HELIUM-NEON LASER WITH  
SUPERIMPOSED MODES EXAMINED BY INTERFERENCE  
PATTERN A66-10337
- DALLAFIOR, E. P.  
HIGH SENSITIVITY FAST-RESPONSE LASER DETECTION  
SYSTEM, DESCRIBING MICROWAVE RESPONSE  
PHOTOELECTRIC DETECTOR WITH AMPLIFICATION AND  
MIXING FUNCTIONS A66-22046
- DALMAN, G. C.  
LINEAR BEAM AND MICROWAVE POWER GENERATION - BEAM-  
CIRCUIT INTERACTION, BASIC CIRCUITS, BEAM-PLASMA  
AMPLIFIER, AND LASER-STIMULATED THERMIONIC
- EMISSION  
RADC-TR-65-22 N65-27099
- DALRYMPLE, G. F.  
CIRCUITRY, MECHANICAL CONSTRUCTION AND PRELIMINARY  
PERFORMANCE OF GALLIUM ARSENIDE LASER TRANSMITTER  
OPERATED AT ROOM TEMPERATURE A65-15327
- DANAY, F.  
PREPARATION OF SINGLE CRYSTALS OF DOUBLE  
MOLYBDATES OF NA AND LA /OR OTHER RARE EARTH  
ELEMENTS/ DOPED WITH ND, TB OR PR FOR LASER  
APPLICATION A66-13478
- DANON, E. K.  
BREAKDOWN OF ARGON BY NEODYMIUM AND RUBY LASER  
PULSES  
REPT.-1935-1 N65-22072
- DANE, J.  
LASER ACTION ON ROTATIONAL LINE IN CARBON DIOXIDE  
AND NITROUS OXIDE VIBRATIONAL SPECTRA IN BOTH P  
AND R BRANCHES UP TO J VALUES OF OVER 50  
A66-23357
- DANEU, V.  
E-LEVEL POPULATION IN RUBY ROD AS FUNCTION OF PUMP  
ENERGY EMITTED BY FLASH TUBE A65-28013
- RUBY LASER OUTPUT EXHIBITING REGULAR SPIKES  
A66-10324
- DANIEL, J. C., JR.  
LASER RADIATION EFFECT ON VERTEBRATE EMBRYOS  
N65-16624
- DANIELSON, G. E., JR.  
NEODYMIUM DOPED GLASS LASER FOUND TO OSCILLATE IN  
CONVENTIONAL RANDOM PULSATING MANNER UNDER MODE-  
LOCKED CONDITIONS A66-21251
- USE OF REFRACTIVE INDEX VARIATION CAUSED BY  
PROPAGATION OF ULTRASONIC WAVES IN LASER  
FEEDBACK INTERFEROMETER TO CONTROL LASER OUTPUT  
C-920083-12 N65-15207
- ULTRASONIC LASER MODULATION TECHNIQUES  
C-920259-3 N65-18440
- MODULATING OUTPUT OF SOLID-STATE LASERS  
D-920259-12 N66-12814
- DANILEIKO, IU. K.  
CONCENTRATION AND TEMPERATURE DEPENDENCE OF SPIN-  
LATTICE RELAXATION TIME IN RUBY AT HELIUM  
TEMPERATURES A66-18257
- CONCENTRATION AND TEMPERATURE DEPENDENCE OF SPIN-  
LATTICE RELAXATION TIME IN RUBY AT HELIUM  
TEMPERATURES A66-20901
- DANILOV, O. B.  
ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS  
LASER WITH PLANE PARALLEL MIRRORS  
A65-15458
- ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS  
LASER WITH PLANE PARALLEL MIRRORS  
A65-28554
- DARICEK, T.  
OSCILLATION SPIKES IN QUASI-CONTINUOUS OPERATION  
OF RUBY LASER AT ROOM TEMPERATURE, NOTING  
THRESHOLD PUMPING ENERGY A66-17532
- DASARO, L. A.  
MICROWAVE AMPLIFICATION ACHIEVED IN SILICON DIODE  
EXHIBITING MICROPLASMA-FREE AVALANCHE  
MULTIPLICATION A65-19227
- DAVID, E.  
LASER EMISSION - STATE-OF-ART SURVEY  
ISL-T-21/63 N66-13536
- DAVIDOVITS, P.  
MAGNETICALLY UNSHIELDED OPTICALLY PUMPED 87 RB  
MASER OSCILLATOR A65-16673
- SELF-SUSTAINED OSCILLATION OBTAINED IN OPTICALLY

- PUMPED RUBIDIUM MASER OPERATING AT TRANSITION  
FREQUENCY OF 6835 MC A65-21873
- OPTICALLY PUMPED RUBIDIUM 87 MASER OSCILLATOR  
A66-24124
- SELF-SUSTAINED RUBIDIUM 87 MASER OSCILLATOR  
N66-10395
- DAVIS, B. I.  
IMMERSION LIQUIDS FOR HIGH ENERGY RUBY LASERS WITH  
MATCHING REFRACTIVE INDEXES TRANSPARENT AT RUBY  
PUMPING AND LASING WAVELENGTHS A65-22625
- DAVIS, D. T.  
MICROWAVE FREQUENCY BEATS IN OFF-AXIS MODES OF  
RUBY LASERS TR-3 N65-35553
- DAVIS, E. K.  
LASER OSCILLATION INCREASE IN EFFICIENCY IN  
NEODYMIUM DOPED GLASS PRODUCED THROUGH ENERGY  
TRANSFER A66-10352
- DAVIS, J. I.  
ATMOSPHERIC TURBULENCE, POWER FLUCTUATION AND  
RADAR DETECTION IN LASER SYSTEMS DESIGN A66-17294
- DAVIS, W. C.  
RUBY LASER AMPLIFIER ENERGY INPUT-OUTPUT  
MATHEMATICAL ANALYSIS AND EXPERIMENTAL  
VERIFICATION A65-17648
- FUSED SILICA OUTPUT COUPLING COMPONENT FOR LASER  
SYSTEM, USING FRUSTRATED TOTAL INTERNAL REFLECTION  
CONFIGURATION A66-17287
- MODEL FOR LASER AMPLIFIER IN WHICH EXCITED  
ELECTRON DENSITY IN HOST LASER MATERIAL IS  
STIMULATED TO PRODUCE OPTICAL ENERGY N65-24343
- DAVIS, W. R.  
CO-60 GAMMA IRRADIATION INDUCED ENERGY OUTPUT  
INCREASE OF RUBY LASER CRYSTAL A65-17687
- GAMMA RADIATION EFFECT ON ENERGY OUTPUT OF RUBY  
LASER CRYSTALS N65-17596
- DAVIT, J.  
FRACTURES IN NEODYMIUM-DOPED ALKALINE SILICATES  
AND BOROSILICATES PRODUCED BY LASER BEAM A66-14174
- DAVY, J. R.  
LASER RANGEFINDER DEVICE PROVIDES FAST AND  
ACCURATE RANGE OF NONCOOPERATIVE TARGETS OPERATING  
ON RADAR PRINCIPLE A65-32586
- DAM, H. A.  
REFRACTIVE INDEX VARIATION DURING LASER OPERATION  
AND CAST-PLASTIC OPTICAL-PUMP CAVITY EQUIPMENT  
FOR PUMPING AND TEMPERATURE CONTROL DURING  
EXPERIMENT SATR-1 N65-15753
- EFFECT OF OPTICAL PUMPING ON ANOMALOUS DISPERSION  
IN SELECTED RUBY LASERS AND VARIATION OF  
REFRACTIVE INDEX DURING LASER OPERATION SATR-3 N65-28619
- DE BUEN, S.  
CHORIORETINAL LESIONS PRODUCED BY LASER ON MONKEY  
AND RABBIT A66-80950
- DE GRUYL, J.  
DEVELOPMENT AND APPLICATION OF IMPROVED MASER  
TECHNIQUES FOR BROADBAND MASER SYSTEM -  
TRAVELING WAVE MASER TECHNIQUES RADC-TR-65-148 N65-32203
- DE GRUYL, J. A.  
SOLID STATE AND MASER TECHNIQUES - BREADBOARD  
EVALUATION, MEASUREMENTS OF LOW-TEMPERATURE  
SEMICONDUCTOR, AND SUPERCONDUCTING THIN FILM  
TUNNELING EFFECTS RADC-TDR-64-480 N65-16017
- SOLID-STATE AND TRAVELING-WAVE MASER TECHNIQUES  
RADC-TR-65-30 N65-33397
- BROADBAND TRAVELING WAVE MASER TECHNIQUES AND  
N-TYPE GERMANIUM SEMICONDUCTOR DEVELOPMENT  
RADC-TR-65-366 N66-15720
- DE LANG, H.  
INTERFEROMETER EXPERIMENT OF HELIUM-NEON LASER  
SHOWS ITS RADIATION OBEYS LAWS OF CLASSICAL OPTICS  
A65-19994
- SMALL STABLE HELIUM-NEON LASER CONSTRUCTION AND  
MODE PATTERNS A65-21256
- TWO POLARIZATION EIGENSTATES OCCURRING  
REPEITIVELY IN MULTIPLE PASS INTERFEROMETER  
CONTAINING ANISOTROPIC ELEMENTS, WITH PLANAR LASER  
EXAMPLE A65-21662
- DE MARIA, A. J.  
USE OF REFRACTIVE INDEX VARIATION CAUSED BY  
PROPAGATION OF ULTRASONIC WAVES IN LASER  
FEEDBACK INTERFEROMETER TO CONTROL LASER OUTPUT  
C-920083-12 N65-15207
- ULTRASONIC LASER MODULATION TECHNIQUES  
C-920259-3 N65-18440
- MODULATING OUTPUT OF SOLID-STATE LASERS  
D-920259-12 N66-12814
- DE SHONG, J. A., JR.  
OPTIMUM DESIGN OF HIGH PRESSURE, LARGE DIAMETER,  
DIRECT NUCLEAR PUMPED, GAS LASERS ANL-7030 N66-11926
- DE WITT, D. P.  
LASER SOURCE REFLECTOMETER TO MEASURE REFLECTANCE  
OF SPECIMENS AT HIGH TEMPERATURE - RELATION OF  
THERMAL EMISSION TO OTHER OPTICAL PROPERTIES  
NBS-TN-267 N66-22418
- DE WOLF, M. Y.  
EFFECT OF LASER RADIATION ON CHEMICAL ACTIVATION  
AND VAPOR FOG NUCLEATION MC-64-110-R1 N65-27760
- DEBEVER, J.-M.  
LASER EMISSION IN PURE CADMIUM SULFIDE CRYSTALS  
BOMBARDED BY ELECTRON BEAMS A66-18650
- DEDKOV, S. V.  
TRENDS IN MASER AMPLIFIERS, DESCRIBING TYPES AND  
DEVELOPMENT TECHNIQUES A65-31408
- DEL PIANO, N. N., JR.  
FABRY-PEROT INTERFEROMETRIC MODULATOR FOR LASER  
BEAM, NOTING ERROR OF PRECISE ALIGNMENT OF  
REFLECTING SURFACES AND GAUSSIAN TYPE OF  
IMPERFECTIONS A66-12202
- DELONE, G. A.  
HYDROGEN MOLECULE MULTIPHOTON IONIZATION,  
DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY  
RUBY LASER EMISSION A66-16517
- HYDROGEN MOLECULE MULTIPHOTON IONIZATION,  
DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY  
RUBY LASER EMISSION A66-20898
- DELONE, N. B.  
SPATIAL DISTRIBUTION OF ELECTRICAL FIELD OBTAINED  
BY FOCUSING RADIATION OF RUBY LASER A66-10250
- HYDROGEN MOLECULE MULTIPHOTON IONIZATION,  
DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY  
RUBY LASER EMISSION A66-16517
- HYDROGEN MOLECULE MULTIPHOTON IONIZATION,  
DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY  
RUBY LASER EMISSION A66-20898
- MULTIPHOTON IONIZATION OF XENON ATOM IN POWERFUL  
ELECTRIC FIELD BY RUBY LASER RADIATION A66-21966

- DELPECH, J. F.  
MODULATION OF HELIUM-NEON LASER BY LIGHT FROM  
HELIUM DISCHARGE A65-33006
- DEMARIA, A. J.  
LASER PULSE-SHAPING AND MODE-LOCKING WITH  
TRAVELING AND STATIONARY ACOUSTIC WAVES IN ARGON  
LASER A65-31763
- MULTIPLE INTERNAL-REFLECTION FOLDED-PATH  
RECTANGULAR LASER CONFIGURATION FOR OBTAINING  
LENGTH OF ACTIVE MEDIA BETWEEN FABRY-PEROT  
REFLECTORS A66-16652
- NEODYMIUM DOPED GLASS LASER FOUND TO OSCILLATE IN  
CONVENTIONAL RANDOM PULSATING MANNER UNDER MODE-  
LOCKED CONDITIONS A66-21251
- DEMARS, G. A.  
LASER OUTPUT SPIKING ELIMINATION USING KERR CELL  
CONTROLLED BY FEEDBACK CIRCUIT A65-24954
- DENTROEDER, W.  
RISE TIME AND OUTPUT POWER OF SINGLE PULSE IN HE-  
NE LASER MEASURED BY METHOD OF CHANGING  
Q-FACTOR BY PLATE LOCATED IN RESONANT CAVITY  
A66-14332
- DER AGOBIAN, R.  
TWO- AND THREE-STEP LASER CASCADES DETECTED  
EXPERIMENTALLY IN HELIUM-NEON MIXTURES, ANALYZING  
TWO-STEP CASCADE STARTING WITH DENSITY MATRIX  
FORMULATION A66-11477
- PREPARATION OF SINGLE CRYSTALS OF DOUBLE  
MOLYBDATES OF NA AND LA /OR OTHER RARE EARTH  
ELEMENTS/ DOPED WITH ND, TB OR PR FOR LASER  
APPLICATION A66-13478
- DESS, H. N.  
GROWTH OF RUBY BOULES ON 60 DEGREE VERNEUIL RODS  
BY CZOCHRALSKI METHOD - LASER APPLICATION  
SACR-65-1 N65-27885
- DETTNER, J. W.  
ARC-TUBE CONSTRUCTED FOR COOLING ARGON ION  
LASER - DISCHARGE TUBE  
GE/EE/65-1 N66-14188
- DEUCHARS, W. M.  
ELECTRON DENSITY MEASUREMENTS IN PLASMA PRODUCED  
BY COMBINATION OF RF AND VERY FAST THETA-PINCH  
DISCHARGES, USING GAS LASER INTERFEROMETER  
A65-29848
- TIME-DEPENDENT ELECTRON DENSITY VARIATION STUDIED  
IN FAST THETA-PINCH DISCHARGE, USING HE-NE GAS  
LASER INTERFEROMETER A65-29849
- DEUEL, R. W.  
MACH-ZEHNDER LASER INTERFEROMETER AS DIAGNOSTIC  
TOOL IN SHOCK TUBE EXPERIMENTS A66-23352
- DEUTSCH, T.  
MODE LOCKING EFFECTS IN INTERNALLY KDP MODULATED  
RUBY LASER A65-35063
- DEVIATKOV, A. G.  
EXCITATION OF SEMICONDUCTOR LASERS BY BEAM OF FAST  
ELECTRONS, DISCUSSING WORK OF SHOCKLEY, POPOV,  
KELDYSH AND KROKHIN A66-17337
- DEVYATKOV, A. G.  
SPECTRAL ANALYSIS OF OUTPUT FROM SINGLE CRYSTAL  
SEMICONDUCTOR GENERATOR EXCITED BY ELECTRON  
BEAM - LASERS  
FTD-TT-65-555/16264 N66-12624
- DHAEMENS, I. J.  
SPONTANEOUS EMISSION NOISE PROPERTIES OF PAIR OF  
PULSED RUBY LASER AMPLIFIERS A66-21310
- DHEER, M. K.  
RUBY LASERS DISCUSSING OUTPUT CHARACTERISTICS,  
BEAM DIVERGENCE, BEAT MODES AND RESPECTIVE  
EXPERIMENTAL TECHNIQUES A66-14919
- DI DOMENICO, M., JR.  
RUBY LASER ROD POSITION ALONG INTERFEROMETER AXIS,
- DETERMINING PRESENCE OF ADJACENT INTERFEROMETER  
MODES A65-25874
- DI FRANCIA, G. T.  
MICROWAVE OR LASER RESONATOR WITH FLAT-ROOF MIRROR  
HAS VERY SMALL DIFFRACTION LOSSES AND IS  
INSENSITIVE TO MISALIGNMENT WHEN ROOF ANGLE IS  
VERY SMALL A65-34606
- LASER CAVITY ANALYSIS, THRESHOLD MEASUREMENTS,  
FREQUENCY DISTRIBUTION, MODE DENSITY, AND  
SPIKING STRUCTURE  
AFCRL-65-481 N65-32298
- DI, T.-C.  
EQUATIONS OBTAINED FROM HAMILTONIAN FOR COUPLING,  
FIRST STOKES LINE, FIRST ANTI-STOKES LINE AND  
COHERENT FIELD FOR RAMAN LASER  
A66-22490
- DIKONOV, M. I.  
DEPENDENCE OF EMISSION INTENSITY OF GAS LASER ON  
LONGITUDINAL AND TRANSVERSE MAGNETIC FIELDS, USING  
SIMPLIFIED MODEL A66-24885
- DICURCIO, A.  
MINORITY CARRIER LIFETIME IN SILICON MEASURED BY  
CONTACTLESS METHOD, USING LASER INDUCED MODULATION  
OF IR TRANSMISSION IN SILICON / LHMIRIS/ EFFECT  
A66-14563
- DIDOMENICO, M., JR.  
MODE LOCKING IN HELIUM-NEON LASER BY MEANS OF  
SYNCHRONOUS INTRACAVITY ACOUSTIC MODULATION IN  
COUPLED MULTIMODE CONFOCAL INTERFEROMETERS  
A65-24276
- LASER CONFIGURATION GENERATING SINGLE FREQUENCY  
RADIATION IN SINGLE SPATIAL MODE WITH HIGH OUTPUT  
ACHIEVED BY SUPPRESSING ALL RESONANCES BUT ONE  
A66-21250
- DIXON, E. O.  
ONE-WATT, ROOM TEMPERATURE, CONTINUOUS OPERATION,  
SUN PUMPED LASER TRANSMITTER  
AD-610601 N65-17927
- DOBSON, C. D.  
SILICON AND SELENIUM DOPING EFFECTS ON GALLIUM  
ARSENIDE LASER CHARACTERISTICS A66-21879
- DORBEK, L.  
CARBON MONOXIDE AND DIOXIDE VIBRATIONALLY INDUCED  
IR EMISSION WITH POSSIBLE APPLICATIONS TO  
CONTINUOUS LASER EMISSION A65-22463
- CONTINUOUS GAS LASER BY DIRECT HF EXCITATION OF  
NITROUS OXIDE AND MIXTURE WITH ARGON IN CAVITY,  
NOTING PERFORMANCES A65-23273
- CONTINUOUS LASER EMISSION DUE TO VIBRATIONAL  
TRANSITIONS IN CARBON DIOXIDE AND NITROUS OXIDE  
MIXTURES EXCITED BY HF SOURCE A65-26292
- LINEAR COEFFICIENT OF AMPLIFICATION OF CARBON  
DIOXIDE SUBJECTED TO HF EXCITATION FIELD FOR  
LASER EMISSION A66-12003
- DOUGAL, A. A.  
QUANTUM ELECTRODYNAMICS IN OPTICAL RESONATORS AND  
MASERS, THERMAL PINCHING, N-TYPE SEMICONDUCTORS,  
COHERENT LIGHT, TRANSISTOR SWITCHING, POPULATION  
INVERSION, AND BREAKDOWN  
AFOSR-65-0248 N65-23491
- COUPLED OPTICAL RESONATOR SYSTEM CHARACTERISTICS  
USING LASER RESONATORS COUPLED TO EXTERNAL  
RESONATORS N65-23492
- MAXWELL EQUATIONS AS MATHEMATICAL MODELS FOR  
SOLUTION OF DIFFRACTION IMAGING THEORY OF  
COHERENT MONOCHROMATIC LIGHT IN MICROSCOPY  
N65-23494
- OPTICAL MASER OUTPUT POWER AFFECTED BY GAS MIXTURE  
AND PRESSURE, RESONATOR GEOMETRY, AND MIRROR  
REFLECTIVITY FOR PLASMA RESEARCH  
N65-23495

- POPULATION INVERSION AND OPTICAL MASER  
OSCILLATIONS IN MOLECULAR GASES  
N65-23497
- THERMONUCLEAR FUSION CONTROL FOR ELECTRIC POWER  
CONVERSION - THETA PINCH, ION CYCLOTRON, AND  
INFRARED MASER DIAGNOSTICS  
N65-24859
- INFRARED MASER INTERFEROMETRY FOR TIME AND SPACE  
RESOLUTION OF ELECTRON DENSITY IN HIGH  
TEMPERATURE PLASMAS  
ARL-65-135  
N66-20024
- DOUSMANIS, G. C.  
ROOM TEMPERATURE OPERATION OF PULSED GALLIUM  
ARSENIDE INJECTION LASER, AND IMPROVEMENT OF  
LASER DIODE STRUCTURE  
ECOM-01501-1  
N66-20809
- DOVYDAITIS, V., JR.  
GAS IONIZATION PHENOMENON AT OPTICAL AND INFRARED  
FREQUENCIES - RUBY LASER INDUCED IONIZATION,  
FOCUSED SPOT DIAMETER, BREAKDOWN EMISSION, AND  
IONIZATION TIMES AND NONATTENUATION  
RADC-TR-64-568  
N65-22250
- DOYLE, W. M.  
ATMOSPHERIC TURBULENCE EFFECT ON OPERATION OF  
DUAL-POLARIZATION FM LASER COMMUNICATION SYSTEM  
A65-33377
- DUCAUZE, A.  
ENERGY AND INTENSITY OF IONS EMITTED BY METAL  
TARGET AS FUNCTION OF CHARACTERISTICS OF LASER AND  
NATURE OF METAL  
A66-15109
- DUMKIN, V. A.  
GAS LASER OUTPUT AND THRESHOLD IN POPULATION  
INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE  
AND FLUORO IODO METHYLIDYNE  
A66-16771
- DUMKER, G. W.  
OPTICAL AND LASER THRESHOLD MEASUREMENTS ON 39  
PLANE-FUSION RUBIES TO OBTAIN HIGHEST OPTICAL  
QUALITY LASER RODS  
A65-16402
- CRYSTALS FOR OPTICAL MASER APPLICATION  
PE-TR-M7920  
N65-16442
- DUNCAN, R. C.  
CONTINUOUS LASER ACTION IN NEODYMIUM DOPED CALCIUM  
MOLYBDATE AT ROOM TEMPERATURE  
A65-21627
- DUNN, S. T.  
LASER SOURCE REFLECTOMETER TO MEASURE REFLECTANCE  
OF SPECIMENS AT HIGH TEMPERATURE - RELATION OF  
THERMAL EMISSION TO OTHER OPTICAL PROPERTIES  
NBS-TN-267  
N66-22418
- DURRETT, R. H.  
WAVELENGTH CHANGE OF SPONTANEOUS AND STIMULATED  
EMISSION WITH UNIAXIAL PRESSURE UNDER CW  
OPERATION OF GA AS DIODE LASER AT 4 DEGREES K  
A66-19922
- DYMACZEWSKI, H.  
POLISH-MADE HE- NE RED GAS LASERS, DESCRIBING  
POWER OUTPUTS, GAS PRESSURE, HE/ NE RATIO,  
MIRROR TRANSMISSION COEFFICIENT AND  
INTERFEROMETRIC APPLICATION  
A66-23946
- DYSON, D. J.  
TIME-VARIATION AND SPONTANEOUS EMISSION FROM HE-  
HG DISCHARGE OF 6149 ANGSTROM LASER TRANSITION  
A65-31451

## E

- EARLY, R. A.  
PLANAR, CONFOCAL, AND SOLID STATE LASERS  
N65-25126
- EBERLY, J. H.  
LASER SCATTERING BY BOUND CHARGED PARTICLES  
A66-23080
- EBINA, Y.  
MASER ACTION TAKING INTO ACCOUNT MIXING OF  
UNPERTURBED SPIN STATES AND DAMPING MECHANISM

- BETWEEN SPIN MOMENTS AND LOCAL FIELD  
A65-16267
- ECKARDT, R.  
LOWER ATMOSPHERE ABSORPTION SPECTRUM STRUCTURE  
FROM 8512 TO 11600 A - NEODYMIUM LASER SPECTRUM  
NRL-6352  
N66-17604
- ECKHARDT, G.  
RAMAN LASER MATERIALS SELECTION, EMPHASIZING  
FREQUENCY SHIFTS AND EXCITATION POWER THRESHOLD  
A66-23477
- ECKHARDT, R. C.  
LASER RESEARCH DEALING WITH EFFECT OF PUMPING ON  
RUBY QUALITY, LANTHANUM FLUORIDE EXAMINATION,  
LARGE RUBY LASER RODS, DC OPERATION OF MERCURY  
TUBE, HOLOGRAMS, AND LASER PHYSICS  
NRL-MR-1604  
N65-28920
- EDWARDS, B. N.  
ABSORPTION OF 3.39 MICRON HELIUM-NEON LASER  
EMISSION BY METHANE IN ATMOSPHERE  
A65-16362
- EFROS, A. L.  
QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION  
AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION  
A65-28487
- QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION  
AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION  
A66-12086
- EGOROV, V. S.  
PLASMA DECAY IN PULSE DISCHARGE OF HELIUM-NEON  
LASER GRAPHICALLY DEPICTED UNDER CONDITIONS OF  
GENERATION  
A65-31878
- PULSE-DISCHARGE PLASMA DECAY STUDIED BY  
OBSERVATION OF GENERATION PROCESSES IN HELIUM-NEON  
PULSE LASER  
A65-33584
- EL-SAYED, M. A.  
OPTICAL PUMPING ENERGY TRANSFER MECHANISM IN RARE  
EARTH CHELATES NOTING POSSIBILITY AS LASER  
MATERIAL  
A65-20075
- ELISEEV, P. G.  
TIME PARAMETERS OF POWERFUL LASER MEASURED WITH  
GA AS PHOTODIODE, NOTING TIME CONSTANT AND TIME  
RESOLUTION OF PHOTODIODE  
A65-34552
- LASER CRYSTALS PREPARED ECONOMICALLY BY SPLITTING  
ALONG CLEAVAGE PLANES  
A66-23293
- ELLIS, A. T.  
RUBY LASER HIGH SPEED PHOTOGRAPHY OF CAVITATION  
DAMAGE TO SOLIDS DUE TO HIGH SPEED JETS FROM  
COLLAPSING BUBBLES  
E-115.1  
N66-21887
- ELLIS, C. B.  
PUMP TRANSFORMER LASERS - CONVERSION TO SINGLE  
PLANE-WAVEFRONT BY ABSORPTION AND RE-EMISSION  
OF MOLECULAR GAS MEDIUM  
GPL-A-31-1  
N65-35530
- METASTABLE NITROGEN MOLECULES AS ACTIVE MEDIUM  
FOR TRANSFORMER LASER PUMPED BY BATTERY OF ND  
GLASS AUXILIARY LASERS  
GPL-A-31-2  
N66-17001
- EMERY, J. C.  
INTERFEROMETER USING SMALL DIFFRACTION GRATING AND  
GAS LASER LIGHT SOURCE IN SCHLIEREN SYSTEM FOR  
FLUID MECHANICS RESEARCH  
A65-25332
- EMMETT, J. L.  
INTENSE UV PUMPING EFFECT ON RUBY LASER OUTPUT  
A66-20519
- CAPACITY MEASUREMENT OF XENON FLASH TUBE - OPTICAL  
MASER  
NASA-CR-56917  
N65-35256
- EMMONS, G. A.  
ATMOSPHERIC EFFECTS ON LASER ENERGY PROPAGATION -  
LITERATURE SURVEY



- RE-TR-65-3 N65-23622
- ENDERLEIN, R.  
LIGHT DIFFRACTION BY GRATING DUE TO FARADAY AND  
KERR EFFECT IN ELECTROMAGNETIC FIELD OF LASER  
BEAM A65-26582
- ENGELER, W.  
TEMPERATURE RISE AT GaAs LASER JUNCTION FOR  
VARIOUS PULSE CURRENTS AND BASE TEMPERATURES  
A65-31732
- ENLOE, L. H.  
EXPERIMENTAL OSCILLATION OF TWO LASERS AT SAME  
FREQUENCY WITH PHASE DIFFERENCE OF LESS THAN ONE  
THIRD DEGREE A65-19603
- EPSTEIN, S.  
LASER EXCITATION IN QUARTZ OF ELASTIC MODES OF  
THICK PLATE, SUGGESTING ENERGY COUPLING MECHANISMS  
A66-12423
- ERHARDT, P. F.  
CONTINUOUS WAVE GAS LASER AND HIGH SPEED MOTION  
PICTURE CAMERA FOR DETECTION OF NEARLY  
CONTINUOUS SET OF LIGHT SCATTERING PHOTOGRAPHS  
FROM POLYETHYLENE POLYMER SAMPLE  
ONR-TR-77 N65-25399
- ERKOVICH, S. P.  
FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS  
SYSTEMS, PRIMARILY LIGHT ABSORPTION AND  
ATMOSPHERIC SCATTERING A65-15349
- FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS  
SYSTEMS, PRIMARILY LIGHT ABSORPTION AND  
ATMOSPHERIC SCATTERING A65-32353
- ERMAKOV, B. A.  
ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS  
LASER WITH PLANE PARALLEL MIRRORS A65-15458
- ANGULAR OSCILLATION MODES IN NEON-HELIUM GASEOUS  
LASER WITH PLANE PARALLEL MIRRORS A65-28554
- ERMAKOVA, N. A.  
COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM  
OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE  
FABRY-PEROT RESONATOR A65-24088
- COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM  
OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE  
FABRY-PEROT RESONATORS A65-34909
- EVENSON, K. H.  
LASER TRANSITION IN VIBRATIONAL STATE OF GROUND  
ELECTRONIC STATE OF CN FROM ROTATIONAL LEVEL 8 TO  
7 WITH POPULATION INVERSION AS RESULT A66-11451
- EVYUNOV, V.  
AXIALLY UNIFORM ENERGY DENSITY IN LASER CAVITY  
OBTAINED, USING BIREFRINGENT SAPPHIRE QUARTER WAVE  
PLATES, RUBY ROD AND TWO MIRRORS A65-16407
- WATER COOLED RUBY LASER CONTINUOUSLY OPERATED AT  
ROOM TEMPERATURE USING ROD IN PUMPING CAVITY A65-19234
- EFFECT OF PARTIALLY SHIELDING RUBY LASER ROD FROM  
PUMP LIGHT UPON LONGITUDINAL MODE SPECTRA OF LASER  
A65-21657
- FREQUENCY SEPARATION BETWEEN TRANSVERSE MODES OF  
RUBY LASER MEASURED BY FABRY-PEROT  
INTERFEROMETER AND VERIFIED BY TRANSVERSE MODE  
SELECTION A65-27610
- EXPERIMENTS ON OPERATING LIFE AND TRANSVERSE MODE  
HOPPING IN CONTINUOUS WAVE RUBY LASER  
IER-7 N65-33421
- EWY, M. D.  
LOCKING OF MODES IN He-Ne LASER AT 6328  
ANGSTROMS, USING EXTERNAL DOPPLER CELL A65-16668
- EYNARD, R.  
RECOMBINATION RADIATION FROM GALLIUM ANTIMONIDE  
P-N JUNCTIONS, OBSERVING STIMULATED EMISSION AND  
LASER ACTION A65-30572
- EYRING, E. M.  
RUBY LASER TEMPERATURE-JUMP RELAXATION KINETIC  
STUDIES OF RAPID REACTIONS  
UUCD-2-64 N66-23078
- ## F
- FADEEV, V. V.  
OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING  
POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED  
POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-15352
- OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING  
POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED  
POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-20893
- FAN, K.-C.  
GAIN BANDWIDTH AND STABILITY OF SOLID STATE  
MULTICAVIDITY MASERS A66-22765
- FANG, L.-C.  
QUANTUM MECHANICAL TREATMENT OF MOLECULAR  
RADIATION BEHAVIOR IN DETUNING CAVITY OF DOUBLE  
CAVITY MASER  
FTD-TT-65-888/1626364 N66-19899
- FARRENQ, R.  
CARBON MONOXIDE AND DIOXIDE VIBRATIONALLY INDUCED  
IR EMISSION WITH POSSIBLE APPLICATIONS TO  
CONTINUOUS LASER EMISSION A65-22463
- LINEAR COEFFICIENT OF AMPLIFICATION OF CARBON  
DIOXIDE SUBJECTED TO HF EXCITATION FIELD FOR  
LASER EMISSION A66-12003
- FARRINGTON, T.  
INTERNAL BUBBLE FORMATION AND CRACKING IN RODS OF  
Q-SWITCHED RUBY AND ND-GLASS LASERS CAUSED BY  
LASER LIGHT, AND IN CASE OF ND-GLASS RODS, BY  
PLATINUM INCLUSIONS IN GLASS A66-13002
- FATUR, L. M.  
NEODYMIUM DOPED CALCIUM TUNGSTATE ROOM TEMPERATURE  
AMPLIFIER AND CW-LASER OSCILLATOR A65-18873
- FAUG, L.-Z.  
COHERENT AND INCOHERENT OUTPUT CURVE OF THREE-  
LEVEL QUANTUM FREQUENCY CONVERTER A65-17505
- FERGUSON, H. I. S.  
LABORATORY RESEARCH ON LASER EXCITATION IN SOLIDS,  
IONIZING RADIATION TRANSMISSION AND PLASMA JETS  
RELATED TO ASTROPHYSICS A65-14678
- SPECTROSCOPIC INVESTIGATION OF LASER EXCITED  
MOLECULAR SPECTRA FROM POWDERED SOLIDS FOR METEOR  
AND REENTRY PHYSICS A65-16382
- FERRAR, C. M.  
NEODYMIUM DOPED GLASS LASER FOUND TO OSCILLATE IN  
CONVENTIONAL RANDOM PULSATING MANNER UNDER MODE-  
LOCKED CONDITIONS A66-21251
- FERTIN, J.  
PHYSICAL CONDITIONS FOR OBTAINING LASER EFFECT IN  
P-N JUNCTION AND TECHNOLOGY IN CONSTRUCTING LASER  
DEVICES A65-23847
- FINIZIE, R. V.  
CHEMICAL PUMPING OF LASERS - EYE DAMAGE IN  
MONKEYS FROM LASER IRRADIATION  
U-3259 N66-13799
- FINK, E. L.  
U V RADIATION STIMULATED EMISSION IN OPTICALLY  
PUMPED POTASSIUM BROMIDE CRYSTALS USEFUL FOR LASER  
EMISSION WHICH IS CONSISTENT WITH POPULATION  
INVERSION EXCITON SCHEME A65-35069

- FIOCCO, G.**  
SENSING OF METEOROLOGICAL VARIABLES BY LASER  
PROBE TECHNIQUES  
NASA-CR-71397 N66-21657
- FISCHER, B.**  
SEPARATION AND FOCUSING OF ATOMIC BEAMS FOR ATOMIC  
HYDROGEN MASERS N65-26679
- FISHER, E. W.**  
SIMULTANEOUS LASER OSCILLATION OBSERVED AT 6943  
AND 6929 ANGSTROM WAVELENGTHS IN NORMAL AND Q-  
SPOILED OPERATION OF RUBY LASER A65-32748
- FITZGERALD, M. E.**  
STIMULATED EMISSION EVIDENCE FROM NITROGEN COOLED  
SPIKING RUBY-LASER-IRRADIATED DEGENERATED P-TYPE  
GA AS CRYSTALS A65-15323
- FLECK, J. A., JR.**  
STABILITY OF CORRECTED COUPLED-MODE LASER EQUATION  
DERIVED FROM MODEL FOR RUBY LASER SPIKING  
RESULTING FROM MODE INTERFERENCE A65-29805
- SPONTANEOUS EMISSION NOISE EFFECTS ON COHERENCE  
PROPERTIES OF LASER A66-21550
- MONTE CARLO METHOD FOR CALCULATION OF EFFECTIVE  
FLUORESCENT LIFE TIMES FOR RUBY LASER RODS WITH  
BREWSTER ANGLE ENDS AND ROUGHENED SIDES  
UCRL-7765-T/REV. 1/ N65-32343
- TIME DEPENDENCY OF COUPLED MODE LASER OSCILLATION  
UCRL-7497 N66-20355
- FLEISHER, M.**  
USE OF OPTICAL MASERS IN DISPLAYS AND PRINTERS -  
DIGITAL ELECTRO-OPTIC LIGHT DEFLECTOR, CEMENTING  
OF CALCITE CRYSTALS, HIGH SPEED ELECTRONIC  
SWITCHES, AND BIREFRINGENT CRYSTALS  
REPT.-6 N65-13857
- FLETCHER, P. C.**  
LASER SURVEILLANCE USING OPTICAL BEAM SCANNING FOR  
DETECTION OF SPACE SATELLITES AND BALLISTIC  
MISSILES  
RADCR-TDR-63-557 N65-22210
- LASER BEACON FOR DAYLIGHT OPTICAL TRACKING -  
COMPONENTS DESCRIPTION, SIGNAL TO NOISE RATIO,  
AND SIGNAL SENSITIVITY  
NASA-CR-62616 N65-23285
- FLINCHBAUGH, D. E.**  
OPTICAL BEAM SCANNING AND LASER OUTPUT MODULATION  
BY MEANS OF ULTRASONIC CELL BUILT AROUND FOCUSING  
CYLINDRICAL SECTION TRANSDUCER A65-28419
- ULTRASONIC LASER MODULATION TECHNIQUES  
C-920259-3 N65-18440
- PEROVSKITE LASER HOST MATERIALS HAVING CUBIC  
CENTROSYMMETRIC CRYSTAL LATTICE SITES  
UACRL-D910269-5 N65-35429
- MODULATING OUTPUT OF SOLID-STATE LASERS  
D-920259-12 N66-12814
- FLOUX, F.**  
PLASMA GENERATION BY FOCUSING LASER BEAM IN AIR AT  
ATMOSPHERIC PRESSURE AND ROOM TEMPERATURE INDICATE  
CONNECTION WITH LUMINOUS ENERGY ABSORPTION DURING  
BREAKDOWN A66-14538
- IONIZATION UNDER LASER ACTION EXTENDED TO METALS  
AND DIELECTRICS, NOTING INFLUENCE ON THRESHOLDS  
A66-17065
- FLOWER, R. A.**  
OPTICAL DIFFRACTION VELOCIMETER LASER NAVIGATION  
SYSTEM A65-29275
- FLYNN, G. W.**  
Q-SWITCHING OF CARBON DIOXIDE AND NITROUS OXIDE  
GAS LASER TRANSITIONS A66-23354
- VIBRATIONAL AND ROTATIONAL RELAXATIONS IN CARBON  
DIOXIDE AND NITROUS OXIDE LASER SYSTEMS, USING Q-  
SWITCHING TECHNIQUES A66-23355
- FOMIN, O. P.**  
DISMOUNTABLE FLASH LAMP FOR LASER, INCLUDING CROSS  
SECTIONAL SCALE DRAWING AND WIRING DIAGRAM A66-23296
- FORBES, D. K.**  
LASER BEAM AMPLIFICATION BY REFLECTION FROM  
SCANNING GAS LASER ACTIVE INTERFEROMETER A65-33047
- GAIN AND BANDWIDTH NARROWING IN REGENERATIVE  
HELIUM-XENON LASER AMPLIFIER A66-12308
- FORBES, W.**  
LASERS FOR MACHINING AND WELDING, NOTING  
PARTICULARLY HE- NE PULSED LASER A65-30540
- FOREMAN, J. W., JR.**  
LASER DOPPLER FLOWMETER MEASUREMENT TECHNIQUE  
FOR LOCALIZED FLOW VELOCITIES IN GAS, NOTING  
RELIABILITY FOR HIGH FLOW VELOCITIES A65-35061
- LASER FLOW METER FOR MEASUREMENT OF LOCAL VELOCITY  
IN CONTAMINATED GAS FLOW FIELDS - DOPPLER SHIFT  
TECHNIQUE R-149 N65-26015
- FOREMAN, W.**  
CONTINUOUS WAVE GAS LASER DOPPLER FLOW METER FOR  
GAS VELOCITY MEASUREMENT N66-22338
- FORESTIERI, A. F.**  
OPTICAL ABSORPTION AND ELECTRON PARAMAGNETIC  
RESONANCE TECHNIQUES USED TO STUDY IONIZING  
RADIATION EFFECT ON RUBY LASERS  
NASA-TN-D-3379 N66-21037
- FORK, R. L.**  
EQUATIONS DESCRIBING HEAT FREQUENCY VARIATION AND  
MODE COMPETITION IN GASEOUS LASER OPERATED IN  
MAGNETIC FIELD PARALLEL TO LASER AXIS A65-30303
- HE- NE GAS LASER OSCILLATING IN TWO LINEARLY  
POLARIZED MODES, COMPARING THEORETICAL AND  
EXPERIMENTAL MODE INTENSITIES AND BEAT FREQUENCIES  
A65-32844
- FORRESTER, P. A.**  
OXYGEN AS CAUSE OF SCATTERING AND CONVERSION OF  
IMPURITIES TO HIGHER VALENCE STATE IN CALCIUM  
FLUORIDE LASER SYSTEM A65-30800
- FOSTER, J. D.**  
FRINGE COUNTING MICHELSON INTERFEROMETER USING  
HELIUM-NEON GAS LASER FOR INDUSTRIAL LENGTH  
MEASUREMENT SCL-DC-65-92 N66-20322
- FOSTER, L. C.**  
LOCKING OF MODES IN HE- NE LASER AT 6328  
ANGSTROMS, USING EXTERNAL DOPPLER CELL A65-16668
- FOURNIER, G. R.**  
LARGE ANGLE DEFLECTION TECHNIQUE FOR PRODUCING  
945-LINE TELEVISION TYPE RASTER SCAN IN DISPLAY  
SYSTEM - ELECTRO-OPTICS, LASERS, AND FIBER  
OPTICS U1-912008-1 N66-14858
- LARGE-ANGLE DEFLECTION METHOD FOR PRODUCTION OF  
TV TYPE RASTER SCAN IN LASER DISPLAY SYSTEM  
U2-912008-2 N66-22498
- FOWLER, V. J.**  
SYSTEM FOR OPTICAL ACQUISITION AND TRACKING, AND  
LASER BEAM DEFLECTOR DEVICES - ELECTRO-OPTICAL  
TECHNIQUES FOR CONTROLLING DIRECTION OF LASER  
BEAM FLOW NASA-CR-64222 N65-30541
- PIEZOELECTRICALLY POWERED LASER BEAM WAVEGUIDE FOR  
ELECTRO-OPTICAL ACQUISITION AND TRACKING

- NASA-CR-68895 N66-17291
- FOWLER, V. J.  
OPTICAL PROPERTIES OF CHANGES IN GAS COMPOSITION  
IN DISCHARGE TUBE FOR HELIUM NEON LASER  
TR-64-257.10 N65-19952
- FOWLES, G. R.  
LASER OSCILLATION IN VISIBLE SPECTRA OF SINGLY  
IONIZED ZINC AND CADMIUM OBTAINED WITH PULSED  
DISCHARGES IN HEATED VAPORS OF THESE METALS MIXED  
WITH NOBLE GASES A65-32747
- LASER OSCILLATION IN VISIBLE REGION FROM PULSED  
COLD CATHODE DISCHARGE IN IONIZED S AND P  
A65-33379
- FOWLES, L. B.  
PLANAR, CONFOCAL, AND SOLID STATE LASERS  
N65-25126
- FOX, D. K.  
SUPERCONDUCTORS APPLIED TO MAGNETS, LASERS AND  
MHD POWER GENERATION A66-20674
- FOX, R.  
FIRST-ORDER RELATIVITY TEST USING PHASE CHANGE OF  
TWO COHERENT BEAMS A66-19935
- CARNAHAN PROPOSED FIRST ORDER ETHER DRIFT  
EXPERIMENT USING TWO LASERS SHOWN TO BE OF SECOND  
ORDER NATURE, NOTING ROLE OF PHASE SHIFTS  
A66-21656
- FRADKIN, E. E.  
INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY  
AFTER LEAVING LASER AND AFTER FOCUSING WITHIN  
LENS, NOTING OPTIMUM FOCUSING CONDITIONS  
A65-36050
- INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY  
AFTER LEAVING LASER AND AFTER FOCUSING WITHIN  
LENS, NOTING OPTIMUM FOCUSING CONDITIONS  
A66-15853
- FRANCOIS, G. E.  
OPTICAL SECOND HARMONIC GENERATION ANGULAR  
VARIATION IN AMMONIUM DIHYDROGEN PHOSPHATE  
GAUSSIAN CW GAS LASER BEAM FOR NONLINEAR  
COEFFICIENT MEASUREMENTS A65-27724
- CONTINUOUS WAVE MEASUREMENT OF OPTICAL  
NONLINEARITY OF AMMONIUM DIHYDROGEN PHOSPHATE,  
USING HELIUM-NEON LASER A66-23716
- FRANCON, M.  
MONOGRAPH ON THEORY OF COHERENCE IN OPTICS  
INCLUDING CONCEPT OF DEGREE IN COHERENCE,  
COHERENCE IN QUASI-MONOCROMATIC LIGHT AND IN  
DIFFRACTION PHENOMENA A65-33897
- FRANK, M. M.  
LASER SCATTERING BY BOUND CHARGED PARTICLES  
A66-23080
- FRANKLIN, A. R.  
SECOND HARMONIC GENERATION AND MEASUREMENT OF  
NONLINEAR POLARIZATION CONSTANT IN ADP, USING  
FOCUSED LASER BEAM A65-16672
- FREE, J.  
EFFECT OF NONUNIFORM SPATIAL INTERACTION BETWEEN  
MODES ON TEMPORAL AND SPATIAL OUTPUT OF RUBY LASER  
A65-33415
- SOLID STATE LASER AMPLIFIER STRUCTURES  
QPR-8 N66-12048
- FREED, C.  
AMPLITUDE NOISE MEASUREMENT FOR CAVITY TYPE  
GASEOUS OPTICAL MASER OSCILLATOR ABOVE AND BELOW  
THRESHOLD A65-19544
- ANODE-CURRENT SPECTRUM OF PHOTOMULTIPLIER  
ILLUMINATED BY LIGHT OF TIME-VARYING INTENSITY AND  
DERIVATION OF MOMENTS OF PHOTOELECTRON COUNTS  
A66-18432
- FREIBERG, R. J.  
QUANTUM-ELECTRONIC CROSS-MODULATION EFFECT NOTED  
WHILE MONITORING IR LASER INTERFEROMETRIC FRINGES  
A66-11449
- FREIDMAN, G. I.  
TRUNCATED EQUATIONS DESCRIBING COHERENT RADIATION  
OF EXCITED CHROMIUM IONS IN RUBY SITUATED IN  
TRAVELING WAVE RESONATOR A65-35919
- FREITAG, H.  
PHYSICAL FUNDAMENTALS OF LASERS SUCH AS POPULATION  
INVERSION, INDUCED EMISSION AND PRINCIPAL OPTICAL  
APPARATUS EXPLAINED FOR COMMUNICATIONS ENGINEERS  
A66-13233
- FRIDGE, D. L.  
LASER SURVEILLANCE USING OPTICAL BEAM SCANNING FOR  
DETECTION OF SPACE SATELLITES AND BALLISTIC  
MISSILES  
RADG-TDR-63-557 N65-22210
- FRIDRIKHOV, S. A.  
LONGITUDINAL MAGNETIC FIELD EFFECT UPON GAS  
DISCHARGE, ZEEMAN EFFECT AND FARADAY EFFECT IN  
HE- NE GAS LASER A66-24224
- FRIED, D. L.  
EFFICIENT DIFFRACTION OF INCIDENT LASER BEAM AT  
BRAGG ANGLE INCIDENCE INTO FIRST-ORDER MODE,  
USING TRAVELING ULTRASONIC WAVES IN WATER  
A65-33057
- FRIEDEN, B. R.  
LOSSLESS CONVERSION OF PLANE LASER WAVE TO PLANE  
WAVE OF UNIFORM IRRADIANCE, NOTING PLANOASPHERIC  
LENSES METHOD AND ABERRATED LENS SYSTEM  
A66-12204
- FRIGERIO, G. E.  
INTENSITY DISTRIBUTION OF FRINGE SYSTEMS USED TO  
VERIFY PHASE INVERSION BETWEEN TWO LOBES OF LASER  
IN TEM-10 MODE A66-17453
- FROELICH, D.  
DECAY OF F-CENTER EXCITATIONS IN ALKALI HALIDES  
INDUCED BY SHORT INTENSE PULSE OF Q-SWITCHED RUBY  
LASER A66-19367
- FROENLY, C.  
SECOND HARMONIC EMISSION AND DIFFRACTION PHENOMENA  
IN KDP CRYSTAL EXCITED BY RUBY LASER BEAM  
A65-29559
- FROMLICH, D.  
DECAY OF LASER-INDUCED EXCITATIONS OF F CENTERS  
IN ALKALI HALIDES  
MSC-387 N65-34867
- FRUENGEL, F.  
TEXT ON HIGH SPEED OPTICAL PULSE TECHNOLOGY,  
LASERS AND MEASURING TECHNIQUES, EMPHASIZING  
CAPACITOR DISCHARGE APPLICATION  
A66-22063
- FUJII, T.  
TRAVELING-WAVE TUBE WITH PHOTOELECTRIC CATHODE  
USED AS DEMODULATOR FOR LASER COMMUNICATION  
A65-14345
- FUJII, Y.  
TRAVELING-WAVE TUBE WITH PHOTOELECTRIC CATHODE  
USED AS DEMODULATOR FOR LASER COMMUNICATION  
A65-14345
- NOISE BEHAVIOR OF POTENTIAL MINIMUM OF TRAVELING  
WAVE TUBES AND REDUCTION FACTOR FOR SHOT NOISE  
DETERMINED, USING LASERS A65-26936

## G

- GALANIN, M. D.  
ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN  
ENERGY ABSORPTION AND POPULATION INVERSION  
A65-36055
- ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN

- ENERGY ABSORPTION AND POPULATION INVERSION  
A66-15858
- GALASSO, F. S.**  
PEROVSKITE LASER HOST MATERIALS HAVING CUBIC  
CENTROSYMMETRIC CRYSTAL LATTICE SITES  
JACRL-D910269-5 N65-35429
- GALEENER, F. L.**  
INDIUM ARSENIDE DIODE SPONTANEOUS AND LASER  
ELECTROLUMINESCENCE IN MAGNETIC FIELDS  
A65-24961
- GALVIN, M. F.**  
CONTINUOUS OPTICAL SECOND-HARMONIC GENERATION  
USING Nd:YAG LASER AND CRYSTAL OF SINGLE-DOMAIN  
LITHIUM NIOBATE A66-16378
- GANDY, H. W.**  
LASER OSCILLATIONS AND SELF Q-SWITCHING,  
DISCUSSING PULSED FLASH-LAMP EXCITATION  
EXPERIMENTS WITH TRIPLY ACTIVATED CONFOCAL BARIUM  
CROWN GLASS ETALON A66-13980
- GANSSEN, A.**  
LOW FREQUENCY MAGNETIC FIELD SENSOR - PROTON  
MASER ANTENNA DESIGN CONSTRUCTION AND  
PERFORMANCE  
RADC-TR-64-567 N65-32211
- GAPONOV, A. V.**  
AUTOMODULATION OF EMISSION FROM SOLID STATE LASER  
A65-24809
- STATISTICAL CHARACTERISTICS OF AUTOMODULATION OF  
SOLID LASER RADIATION N65-27234
- GARAZHA, S. A.**  
EFFECTS OF RESONATOR LENGTH AND MIRROR  
TRANSPARENCY AND ALIGNMENT UPON DYNAMIC AND STATIC  
CHARACTERISTICS OF RUBY LASER WITH MODULATED  
Q-FACTOR A65-35786
- GARDASHIAN, V. M.**  
RUBY LASER THRESHOLD PUMPING AND EMISSION ENERGIES  
RELATED TO TRANSMISSION COEFFICIENT, ROD DIAMETER  
AND THRESHOLD LEVEL A65-20343
- GARFINKEL, M.**  
TEMPERATURE RISE AT GaAs LASER JUNCTION FOR  
VARIOUS PULSE CURRENTS AND BASE TEMPERATURES  
A65-31732
- GARRIRE, E.**  
COHERENTLY DRIVEN MOLECULAR VIBRATIONS AND LIGHT  
MODULATION - RAMAN SCATTERING BY MASER BEAM  
NASA-CR-58211 N65-14531
- STIMULATED BRILLOUIN SCATTERING OF INTENSE LASER  
LIGHT WITH BUILD-UP OF COHERENT HYPERSONIC WAVES  
IN LIQUIDS  
NASA-CR-58214 N65-33710
- DYNAMICS AND CHARACTERISTICS OF SELF-TRAPPING OF  
INTENSE LIGHT BEAMS  
NASA-CR-74030 N66-23765
- GARRETT, C. G. B.**  
FAR IR GAS MASER OSCILLATOR DISCUSSING ENERGY  
LEVELS, PUMPING MOLECULAR RADIATION AND DETECTION  
A65-18849
- GATES, J. W.**  
OPTICAL AMPLIFICATION OF APPARENT RATE OF  
REFLECTOR ROTATION IN Q-SWITCHING OF LASER  
RESONATOR A65-26946
- GATLAND, I. R.**  
PROPOSED EXPERIMENT TO OBSERVE STIMULATED PHOTON -  
PHOTON SCATTERING WITH LASER POWER  
N65-31459
- GATOS, H. C.**  
SOLID STATE PHYSICS, SEMICONDUCTOR DEVICES, LASER  
RESEARCH, AND MATERIALS  
ESD-TDR-65-71 N66-15609
- GAVRILOV, V. M.**  
RUBY LASER OUTPUT RADIATION CHANGE DUE TO  
PHTHALOCYANINE SOLUTIONS PLACED IN RESONATOR  
CAVITY A65-21071
- GIANT LASER EMISSION PULSES IN NEODYMIUM ACTIVATED  
GLASS ROD BY VARYING CAVITY Q WITH QUINOLINE  
SOLUTION OF POLYMETHINE DYE A65-27554
- RUBY LASER OUTPUT RADIATION CHANGE DUE TO  
PHTHALOCYANINE SOLUTIONS PLACED IN RESONATOR  
CAVITY A65-31236
- GEBBIE, H. A.**  
REFRACTIVE INDEX OF SOLID DETERMINED, USING FAR  
IR MICHELSON INTERFEROMETER ILLUMINATED WITH  
RADIATION FROM CN MASER A65-24683
- GEBHARDT, F. G.**  
OPTICAL RADAR TECHNIQUES - STUDIES OF NEAR  
HEMISPHERICAL RESONATOR GAS LASER  
REPT.-1641-6 N66-12795
- GEBHART, J.**  
INTERFERENCE EFFECTS AT THIN TRANSPARENT  
CYLINDRICAL GLASS FIBERS EXPOSED TO COHERENT LIGHT  
FROM He-Ne LASER A66-10368
- LASER-BEAM SCATTERING BY INDIVIDUALLY INTRODUCED  
CHARGED POLYSTYRENE SPHERICAL PARTICLES AND  
DROPLETS OF NAPHTHALENE AND WATER IN COMBINATION  
A66-17473
- GEDEN, D.**  
GC/S NITROGEN-COOLED NONDEGENERATE PARAMETRIC  
AMPLIFIER, NOTING DESIGN, APPLICATION AND  
OPERATION CHARACTERISTICS A66-21857
- GEHMAN, B. L.**  
CUT-OFF OF RUBY LASER EMISSION BY PULSED ELECTRON  
AND BREMSSTRAHLUNG RADIATION, USING ADIABATIC  
TEMPERATURE A66-12447
- GEHRER, G.**  
MODES OF EMISSION-VS-TIME SPECTRUM, OPTICAL  
EMISSION SPECTRUM AND SUPERPOSITION SPECTRUM OF  
SHORT CONFOCAL RUBY LASER IN NEAR FIELD  
A66-14290
- MODE SELECTIVE CHARACTERISTICS OF PLANE-PARALLEL  
DIELECTRIC PLATE AS REFLECTOR FOR RUBY LASER  
RESONATOR A66-14330
- GENKIN, V. N.**  
DEGREE OF EXCITATION OF METASTABLE STATE  
DETERMINED, USING LUMINESCENCE SATURATION  
PHENOMENON, CALCULATING POPULATION OF WORKING  
LEVEL OF LASER SUBSTANCE A66-22027
- GEORGE, E. W.**  
LASER DOPPLER FLOWMETER MEASUREMENT TECHNIQUE  
FOR LOCALIZED FLOW VELOCITIES IN GAS, NOTING  
RELIABILITY FOR HIGH FLOW VELOCITIES  
A65-35061
- LASER FLOW METER FOR MEASUREMENT OF LOCAL VELOCITY  
IN CONTAMINATED GAS FLOW FIELDS - DOPPLER SHIFT  
TECHNIQUE  
R-149 N65-26015
- GEORGE, T. V.**  
NOBLE GAS MOLECULAR SCATTERING OF RUBY LASER LIGHT  
COMPARED WITH RAYLEIGH THEORY A65-15438
- GERARDO, J. B.**  
TIME RESPONSE OF HF LASER INTERFEROMETER USED IN  
PLASMA RESONANCE DETECTION A65-29791
- LASER INTERFEROMETER AND APPLICATION TO PLASMA  
PHYSICS  
AROD-4832-2 N65-17210
- GERBER, E. A.**  
RUBY LASER WITH VIBRATING MIRROR FOR STUDY OF  
TEMPORAL OUTPUT MEASUREMENTS N65-22759
- GERBER, W. D.**  
ATMOSPHERIC TURBULENCE EFFECT ON OPERATION OF  
DUAL-POLARIZATION FM LASER COMMUNICATION SYSTEM  
A65-33377

- GERHARTZ, R.**  
POLARIZATION EFFECT ON ENERGY DISTRIBUTION AND  
EFFICIENCY IN DIFFRACTION GRATING OF ATTENUATED  
LASER LIGHT A65-16581
- GERRITSEN, H. J.**  
ABSORPTION DATA FOR METHANE AND ETHANE, USING HE-  
NE TUNED LASER SPECTROSCOPY A65-20064
- C M LASER ACTION ON TRIPLE STATE PHOSPHORUS-SULFUR  
TRANSITION, USING HYDROGEN SULFIDE-NOBLE GAS  
MIXTURES A66-21577**
- GERRY, E. T.**  
THOMSON SCATTERING SPECTRUM OF LASER BEAM FROM  
EQUILIBRIUM HYDROGEN PLASMA, NOTING EFFECT OF  
DEBYE LENGTH A65-17151
- PULSED MOLECULAR NITROGEN LASER THEORY VIA  
ELECTRON IMPACT EXCITATION OF TRIPLET STATES  
A65-33050**
- LASER ACTION AT 5401 ANGSTROMS IN PURE NEON PULSED  
HIGH VOLTAGE DISCHARGE A66-10353**
- GEUSIC, J. E.**  
COHERENT HIGH POWER PULSES FROM OPTICALLY PUMPED  
Y A G-ND LASER BY Q-SWITCHING FROM MIRROR  
ROTATION A65-26003
- LASER CHARACTERISTICS OF AND COHERENT OSCILLATIONS  
FROM TRIVALENT TM, HO, YB AND ER IONS IN  
YTTRIUM ALUMINUM GARNET A66-10241**
- REPETITIVE HIGH POWER PULSES OBTAINED BY  
Q-SWITCHING OF NEODYMIUM-LOADED YTTRIUM  
ALUMINUM GARNET LASER  
QR-6 N65-30870**
- SOLID STATE OPTICAL MASER RESEARCH - YTTRIUM-  
ALUMINUM-GARNET NEODYMIUM LASER OSCILLATOR AS  
REGENERATIVE NOISE AMPLIFIER - AMPLITUDE  
FLUCTUATIONS  
QR-7 N66-14272**
- GIBBS, W. E. K.**  
POLARIZATION EFFECTS IN RUBY LASER CONSISTING OF  
RIGHT-ANGLE ROOF-TOPPED ROD WITH C AXIS  
PERPENDICULAR TO ROOF EDGE, EXTERNAL MULTILAYER  
DIELECTRIC REFLECTOR AND HELICAL FLASH TUBE  
A65-29530
- GIBSON, F. W.**  
CLEAR AIR TURBULENCE DETECTION WITH LASER DOPPLER  
OPTICAL RADAR  
AIAA PAPER 66-374 A66-24498
- GILLESPIE, D. E.**  
LASER SIMULATED NUCLEATION IN BUBBLE CHAMBER,  
COMPARING SENSITIVITY WITH RADIOACTIVELY  
STIMULATED NUCLEATION A66-21583
- GILLILLAND, K. E.**  
WAVELENGTH OF 3S2-2P4 TRANSITION OF NEON MEASURED,  
USING HELIUM-NEON LASER A66-16387
- ABSOLUTE WAVELENGTH STABILITY OF HELIUM-NEON LASER  
MEASURED BY DIRECT INTERFEROMETRIC COMPARISON WITH  
HG 198 STANDARD LAMP A66-22868**
- GILLMER, A. H.**  
GAIN COEFFICIENTS AND MEASUREMENTS IN LASER  
AMPLIFIER, AND SOLID STATE LASER MATERIALS  
QR-6 N65-14465
- SOLID STATE LASER AMPLIFIER STRUCTURES  
QPR-8 N66-12048**
- GILMOUR, A. S., JR.**  
PRODUCTION OF ION VELOCITIES OVER 4 KM/SEC BY  
FOCUSED RUBY LASER MAKES PRACTICAL APPLICATION IN  
DIRECT THRUSTORS AND AS PLASMA SOURCE IN  
ACCELERATOR TYPE THRUSTORS A65-23626
- ELECTRON AND ION EMISSION FROM PULSED RUBY LASER  
ILLUMINATED METALLIC SURFACE INTO VACUUM,  
DETERMINING APPLICATION TO PULSED ION THRUSTOR  
AIAA PAPER 66-230 A66-21453**
- GINTHER, R. J.**  
LASER OSCILLATIONS AND SELF Q-SWITCHING,  
DISCUSSING PULSED FLASH-LAMP EXCITATION  
EXPERIMENTS WITH TRIPLY ACTIVATED CONFOCAL BARIUM  
CROWN GLASS ETALON A66-13980
- GINTOFT, R. I.**  
OUTPUT POWER AND PULSE DURATION OF RUBY LASER  
A66-12602
- GIORI, F. A.**  
PRODUCTION OF ION VELOCITIES OVER 4 KM/SEC BY  
FOCUSED RUBY LASER MAKES PRACTICAL APPLICATION IN  
DIRECT THRUSTORS AND AS PLASMA SOURCE IN  
ACCELERATOR TYPE THRUSTORS A65-23626
- ELECTRON AND ION EMISSION FROM PULSED RUBY LASER  
ILLUMINATED METALLIC SURFACE INTO VACUUM,  
DETERMINING APPLICATION TO PULSED ION THRUSTOR  
AIAA PAPER 66-230 A66-21453**
- GIULIANO, C. R.**  
SPONTANEOUS EMISSION NOISE PROPERTIES OF PAIR OF  
PULSED RUBY LASER AMPLIFIERS A66-21310
- DISPERSION EFFECTS IN LASER AMPLIFIERS  
AFOSR-65-2211 N66-16411**
- GLAS, P.**  
SELECTIVE REFLECTION AND DISPERSION PATTERNS NEAR  
RED RUBY LINES, USING RUBY LASER AS LIGHT SOURCE  
A65-33587
- GLASSGOLD, A. E.**  
QUANTUM STATISTICAL PROCEDURE DEVELOPED FOR  
RADIATION FIELD AND APPLIED TO LASER AMPLIFIERS  
A65-32707
- QUANTUM STATISTICS FOR ANALYZING RADIATION FIELDS  
INTERACTING WITH OTHER SYSTEMS APPLIED TO MODEL  
LASER OPERATING AS LINEAR AMPLIFIER A66-13260**
- QUANTUM AND CLASSICAL MECHANICAL THEORIES OF LASER  
RADIATION  
RM-4435-PR N65-19297**
- QUANTUM STATISTICAL PROCEDURE FOR STUDYING  
INTERACTING RADIATION FIELD APPLIED TO MODEL  
LASER OPERATING AS LINEAR AMPLIFIER  
RM-4516-PR N65-27655**
- GLAUBER, R. J.**  
RELATION BETWEEN OPTICAL COHERENCE AND PHOTON  
STATISTICS, USING CLASSICAL AND QUANTUM THEORY,  
INTERFERENCE EXPERIMENTS AND PHOTODETECTION  
A65-24002
- GLOGE, D.**  
IRREGULAR BENDS AND LENS DISPLACEMENTS EFFECT ON  
WAVELENGTH AND MODES IN LASER WAVEGUIDE  
A66-23103
- GOERLICH, P.**  
SPECTROSCOPIC DATA ON ABSORPTION, SPONTANEOUS  
FLUORESCENCE AND STIMULATED EMISSION IN ACTINIDES,  
TRANSITION METAL AND SEMICONDUCTOR LASER MATERIAL  
A65-21168
- GOETZBERGER, A.**  
MICROWAVE AMPLIFICATION ACHIEVED IN SILICON DIODE  
EXHIBITING MICROPLASMA-FREE AVALANCHE  
MULTIPLICATION A65-19227
- GOLD, L.**  
PROPOSED EXPERIMENT TO OBSERVE STIMULATED PHOTON -  
PHOTON SCATTERING WITH LASER POWER  
N65-31459
- GOLDICK, H. D.**  
FREQUENCY STABILIZATION OF DOUBLE MODE HELIUM-NEON  
LASER VIA PHASE LOCK CIRCUIT A65-29411
- GOLDSTEIN, B. S.**  
CIRCUITRY, MECHANICAL CONSTRUCTION AND PRELIMINARY  
PERFORMANCE OF GALLIUM ARSENIDE LASER TRANSMITTER  
OPERATED AT ROOM TEMPERATURE A65-15327

- GOLDSTEIN, L.**  
NOBLE GAS MOLECULAR SCATTERING OF RUBY LASER LIGHT  
COMPARED WITH RAYLEIGH THEORY A65-15438
- GOLDSTEIN, R. J.**  
AERODYNAMIC AND HEAT TRANSFER MEASUREMENTS USING  
INTERFEROMETER WITH CONTINUOUS WAVE LASER AS  
SOURCE A66-10849
- GOLUBEV, G. P.**  
FORCED EMISSION FROM ELECTRON-EXCITED CADMIUM  
SELENIDE A66-22174
- GONCHARENKO, A. M.**  
STIMULATED EMISSION OF ELECTROMAGNETIC WAVES FROM  
CIRCULAR CYLINDER AND SPHERE A65-17219
- CIRCULAR DIELECTRIC RESONATOR UNDER CRITICAL  
OPERATING CONDITIONS IN ANALYSIS OF PERFORMANCE  
AND ENERGY LOSS A65-36011
- GONCHAROV, I. G.**  
HELIUM-NEON LASER MODULATION BY POSITIVE AND  
NEGATIVE VOLTAGE PULSES A65-35931
- GONDA, T.**  
REABSORPTION AS DOMINANT LOSS MECHANISM FOR BOTH  
INCOHERENT AND COHERENT RADIATION IN GALLIUM  
ARSENIDE LUMINESCENT DIODE A65-30347
- TIME RESOLVED SPECTRA FOR PULSE OPERATED GALLIUM  
ARSENIDE LASER DIODES A65-33372
- HOLE AND ELECTRON SMEARING AND P-TYPE ABSORPTION  
INFLUENCE ON THRESHOLD CURRENT A66-23478
- GOODWIN, D. W.**  
LASER ACTION THEORY IN CRYSTALLINE OPTICAL SOLID,  
DISCUSSING PROMISING MATERIALS AND MULTIPHONON  
PROCESSES IMPORTANCE IN LINE WIDTH AND TRANSITION  
PROBABILITIES A65-19997
- GOODWIN, F. E.**  
CARBON AND ETHYLENE TETRACHLORIDE ULTRASONIC  
MODULATORS APPLIED TO IR LASER HETERODYNE  
EXPERIMENTS ON IN AS PHOTODIODE A66-23353
- GORBAN, I. S.**  
CHROMIUM INDUCED LIGHT DISPERSION IN R LINES OF  
RUBY, NOTING REFRACTION SHIFT IN LASER SPECTRUM  
A65-20260
- GORBUNOV, V. M.**  
SPATIAL DISTRIBUTION OF ELECTRICAL FIELD OBTAINED  
BY FOCUSING RADIATION OF RUBY LASER A66-10250
- RUBY LASER WITH CONCENTRIC RESONATOR AS  
ILLUMINATION SOURCE OF BUBBLE CHAMBER A66-11189
- RUBY LASER WITH CONCENTRIC RESONATOR AS  
ILLUMINATION SOURCE OF BUBBLE CHAMBER A66-24010
- GORDON, E. I.**  
CONSTRUCTION PROBLEMS OF CONTINUOUS-DUTY DC  
EXCITED ION LASERS A66-13956
- GORDON, J. P.**  
BUILDUP AND DECAY TRANSIENT EFFECTS IN GAS LASERS  
DUE TO LIGHT ABSORPTION BY INSERTED LIQUID SAMPLES  
A65-15816
- GORI, F.**  
COHERENCE PROPERTIES OF HELIUM-NEON LASER WITH  
SUPERIMPOSED MODES EXAMINED BY INTERFERENCE  
PATTERN A66-10337
- GORMEZANO, C.**  
DENSITY, TEMPERATURE AND SPEED OF EXPANSION OF  
PLASMA CLOUD PRODUCED BY IMPACT OF RUBY LASER BEAM  
ON ALUMINUM STRIP A65-29558
- GOULD, G.**  
GAS DISCHARGE COLLISION LASER EFFICIENCY AND POWER  
OUTPUT CONSIDERATIONS WITH ATTENTION TO MANGANESE  
AND LANTHANUM DISCHARGES A65-20062
- C W IR LASER OSCILLATION IN H BR AND HI GAS  
DISCHARGE A66-16756
- LASER ACTION ON FIVE GREEN LINES AND SIX IR LINES  
CAUSED BY PULSING MANGANESE DISCHARGE OF COLLISION  
LASER IN ATOMIC VAPOR OF NEUTRAL MANGANESE  
A66-16763
- GRAFINGER, A. B.**  
LASER RANGING EXPERIMENTS PERFORMED WITH BEACON  
EXPLORER B A65-21303
- GRAFT, R. D.**  
MODEL FOR BEHAVIOR OF OPTICAL MASER IN STATIC  
MAGNETIC FIELD OF ARBITRARY STRENGTH IN Z  
DIRECTION AND IN ELECTROMAGNETIC FIELD COMPOSED OF  
TRAVELING WAVES A66-13135
- GRAHAM, M. E.**  
IMMERSION LIQUIDS FOR HIGH ENERGY RUBY LASERS WITH  
MATCHING REFRACTIVE INDEXES TRANSPARENT AT RUBY  
PUMPING AND LASING WAVELENGTHS A65-22625
- GRANGEON, M. J.**  
NOISE TEMPERATURE MEASUREMENT OF RUBY MASER,  
CONSIDERING GAIN STABILITY AND BANDPASS WIDTH  
A65-30378
- GRANITSAS, G. A.**  
PREPARATION OF OPTICALLY HOMOGENEOUS LASER GLASS  
FREE OF PLATINUM INCLUSIONS BY PLATINUM  
PASSIVATION OR USING ALL-CERAMIC MELTING SYSTEM  
SATR-1 N65-22027
- PREPARATION OF PLATINUM-FREE LASER GLASS  
SATR-2 N66-14672
- GRASIUK, A. Z.**  
SELF-PULSED MODULATION MODE STABILIZATION OF TWO-  
LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK A65-14144
- SELF-PULSED MODULATION MODE STABILIZATION OF TWO-  
LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK A65-24019
- EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER  
WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF  
FORBIDDEN BAND IN GALLIUM ARSENIDE A65-31307
- EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER  
WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF  
FORBIDDEN BAND IN GALLIUM ARSENIDE A65-33354
- INDUCED RADIATION IN GA AS SEMICONDUCTOR CRYSTAL  
EXCITED BY RUBY LASER WITH Q-MODULATION A65-35842
- INDUCED RADIATION AND LASER ACTION OF GALLIUM  
ARSENIDE SINGLE CRYSTAL EXCITED BY LIGHT FROM  
Q-MODULATED RUBY LASER A65-36362
- GENERATION IN CADMIUM SULFIDE DURING TWO-PHOTON  
OPTICAL EXCITATION BY RUBY LASER WITH MODULATED  
Q-FACTOR A66-19620
- GRATTON, F.**  
PLASMA PRODUCTION USING GIANT LASERS FOCUSED ON  
SMALL SPECKS OF SOLID MATERIAL A65-30792
- GREEN, G. W.**  
OXYGEN AS CAUSE OF SCATTERING AND CONVERSION OF  
IMPURITIES TO HIGHER VALENCE STATE IN CALCIUM  
FLUORIDE LASER SYSTEM A65-30800
- GREENE, R. L.**  
INTENSE UV PUMPING EFFECT ON RUBY LASER OUTPUT  
A66-20519
- GREGG, D.**  
OPTICAL BEAM DIVERGENCE OF 6943 ANGSTROM LIGHT  
CAUSED BY SINGLE PASS THROUGH RUBY LASER AMPLIFIER  
DURING PUMPING A65-29529
- GREYTAK, T.**  
BRILLOUIN SCATTERING IN LIQUIDS EXAMINING  
VELOCITY, FREQUENCY AND LIFETIME OF THERMALLY

- EXCITED HYPERSONIC SOUND WAVES, USING LASER LIGHT SOURCES A66-12422
- GRIAZNEV, I. N.  
RUBY LASER OUTPUT RADIATION CHANGE DUE TO PHTHALOCYANINE SOLUTIONS PLACED IN RESONATOR CAVITY A65-21071
- GIANT LASER EMISSION PULSES IN NEODYMIUM ACTIVATED GLASS ROD BY VARYING CAVITY Q WITH QUINOLINE SOLUTION OF POLYMETHINE DYE A65-27554
- RUBY LASER OUTPUT RADIATION CHANGE DUE TO PHTHALOCYANINE SOLUTIONS PLACED IN RESONATOR CAVITY A65-31236
- GRIBBLE, R. F.  
INFRARED MASER INTERFEROMETRY FOR TIME AND SPACE RESOLUTION OF ELECTRON DENSITY IN HIGH TEMPERATURE PLASMAS ARL-65-135 N66-20024
- GRIFFIN, P. M.  
INEXPENSIVE SIMPLIFIED CONSTRUCTION OF DC POWERED HELIUM NEON LASER WITH 6328 ANGSTROM OUTPUT A65-19849
- GRIGORIANTS, V. V.  
RESONATOR MADE OF MAGNETIC MATERIALS FOR TUNING MOLECULAR GENERATOR BY ZEEMAN MODULATION A66-20792
- GRINES, M. H.  
OPTICAL ABSORPTION AND ELECTRON PARAMAGNETIC RESONANCE TECHNIQUES USED TO STUDY IONIZING RADIATION EFFECT ON RUBY LASERS NASA-TN-D-3379 N66-21037
- GROSS, R. A.  
MAGNETIC FIELD PROBE IN ELECTROMAGNETICALLY DRIVEN SHOCK TUBE AND COHERENT LIGHT IN IONIZING SHOCK WAVE PLASMA DIAGNOSTICS A65-29569
- GUBIN, S.  
SYSTEMS ANALYSIS OF LASERS VS MICROWAVES FOR MARS-TO- EARTH COMMUNICATIONS IN 1970 A65-28248
- SPACE COMMUNICATION REQUIREMENTS USING LASERS AND MICROWAVES IN MANNED MARS FLIGHTS AIAA PAPER 65-324 A65-30519
- GUZENKO, L. I.  
PHOTON ROCKET ENGINE USING PLASMA LASER EMISSION A65-18375
- GUENTHER, A. H.  
LASERS AS TRIGGERING MECHANISM FOR SPARK GAPS, NOTING DELAY TIME BETWEEN PULSE ARRIVAL AND CURRENT FLOW A66-13247
- GAS SPECTROSCOPY OF LASER-INDUCED STIMULATED BRILLOUIN EFFECT IN HIGH PRESSURE OXYGEN A66-23432
- GUERS, K.  
HIGH SYMMETRY OSCILLATIONS IN CONTINUOUS WATER COOLED SOLID STATE LASERS, SHOWING RELATION TO EXCITATION CONDITIONS A65-14185
- OSCILLATORY BEHAVIOR OF NEODYMIUM DOPED CALCIUM TUNGSTATE SOLID STATE LASERS WITH CW EMISSION BASED ON RATE EQUATIONS A65-19998
- SPIKEFREE EMISSION FROM LASER USING LONG RUBY CRYSTAL DOPED HEAVILY WITH CHROMIUM AND SUITABLE SYMMETRY FOR PUMP RADIATION A66-14331
- GUILLAUME, C. B. A LA  
LASER EMISSION IN PURE CADMIUM SULFIDE CRYSTALS BOMBARDED BY ELECTRON BEAMS A66-18650
- GUNNICK, J. L.  
IMPROVED QUANTUM EFFICIENCY FROM LIGHT TRAPPED IN TRANSLUCENT PHOTOCATHODE LASER DETECTORS ITIL-66-1002 N66-20166
- GURS, K.  
RELAXATION OSCILLATIONS IN EMISSION OF RUBY LASERS UNDER VARIOUS OPERATIONAL CONDITIONS T-6-215 N65-24968
- GUSINOV, M. A.  
TIME RESPONSE OF HF LASER INTERFEROMETER USED IN PLASMA RESONANCE DETECTION A65-29791
- LASER INTERFEROMETER AND APPLICATION TO PLASMA PHYSICS ARDD-4832-2 N65-17210
- GVALADZE, T. V.  
RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING TOTAL REFLECTION PRISM A65-18462
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING TOTAL REFLECTION PRISM A65-28091
- ## H
- HAAKE, F.  
LASER SYSTEM COHERENCE PROPERTIES OF STATISTICAL OPERATOR R IN LIGHT FIELD, USING SCHROEDINGER EQUATION ASSUMING GLAUBER STATE A65-25265
- MASTER EQUATION FOR COMPLETE STATISTICAL OPERATOR OF SOLID STATE LASER ACCORDING TO QUANTUM MECHANICS A65-31773
- HABING, D. H.  
PULSED IR LASER SIMULATING RADIATION-INDUCED TRANSIENT IONIZATIONS IN SEMICONDUCTOR DEVICES AND CIRCUITS A66-14853
- HADDAD, G. I.  
PUMP FREQUENCY OF 30 GIGACYCLES USING HARMONIC CROSS RELAXATION ON CHROMIUM DOPED RUTILE TO OBTAIN POPULATION INVERSION AT 40 GIGACYCLE SIGNAL FREQUENCY A65-25873
- HADDAD, T. A.  
FABRICATION AND TEST OF CONTINUOUS WAVE LASER ACTION FROM DYSPROSIUM IN CALCIUM FLUORIDE EXCITED BY TUNGSTEN LAMP A65-19184
- HAEFELE, H.-G.  
RUBY LASER TEMPERATURE MEASUREMENT AND FILTERING BY DETERMINING SPECTRAL POSITION OF POLARIZATION INTERFERENCE BANDS A65-14184
- HAGENAH, W. D.  
LASER APPLICATION IN CHEMICAL COMPOSITION ANALYSIS OF MATERIAL BY SPECTROSCOPIC TECHNIQUE, CONSIDERING ORGANIC SUBSTANCE AND PLASMA A65-20004
- HAGENLOCKER, E. E.  
STIMULATED BRILLOUIN AND RAMAN SCATTERING IN GASES, DISCUSSING SOUND VELOCITY CALCULATION FROM FREQUENCY SHIFT AND ARGON, HYDROGEN AND NITROGEN A66-13981
- HAHN, E. L.  
STIMULATED EMISSION FROM CHROMIUM IONS IN Q-SPOILED RUBY LASER A65-35066
- HAIL, R. G. W.  
OPTICAL AMPLIFICATION OF APPARENT RATE OF REFLECTOR ROTATION IN Q-SWITCHING OF LASER RESONATOR A65-26946
- HAISHA, J.  
HE- NE LASER PROPERTIES AND LASER MECHANISM OF NE ATOMS, NOTING TRANSITION PROCESS AND OSCILLATION DYNAMICS A65-19999
- SMALL STABLE HELIUM-NEON LASER CONSTRUCTION AND MODE PATTERNS A65-21256
- HAKEN, H.  
TWO- AND THREE-STEP LASER CASCADES DETECTED EXPERIMENTALLY IN HELIUM-NEON MIXTURES, ANALYZING TWO-STEP CASCADE STARTING WITH DENSITY MATRIX FORMULATION A66-11477
- QUANTUM MECHANICAL NONLINEAR THEORY OF INTENSITY AND PHASE FLUCTUATIONS OF HOMOGENEOUSLY BROADENED LASER NOISE A66-22466

**HALDEMANN, P.**  
ALUMINUM COLD CATHODES WITH SINGLE MODE  
6328 ANGSTROM HELIUM-NEON GAS LASER LIFETIMES  
EXCEEDING 3000 HOURS A66-10855

**HALL, R. N.**  
SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION,  
CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION,  
FREQUENCY MODULATION LASERS, AND GALLIUM  
COMPOUND INGOTS FOR LASER APPLICATION  
AFCRL-64-1007 N65-23135

FREQUENCY MODULATION LASER WITH COMPOSITE AXIAL  
MODES N65-23138

**HALSEY, H. W.**  
LASER RANGING EXPERIMENTS PERFORMED WITH BEACON  
EXPLORER B A65-21303

**HAM, I.**  
LASER WELDING EVALUATED WITH REGARD TO PERFORMANCE  
AND PRODUCTION APPLICATION A66-14692

**HAMAL, K.**  
OSCILLATION SPIKES IN QUASI-CONTINUOUS OPERATION  
OF RUBY LASER AT ROOM TEMPERATURE, NOTING  
THRESHOLD PUMPING ENERGY A66-17532

**HAMBLETON, K. G.**  
OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER  
AS AIRCRAFT ALTITUDE METER TO ELIMINATE SPURIOUS ECHOES  
A65-32588

DESIGN OF COMPACT 100 WATT GALLIUM ARSENIDE LASER  
TRANSMITTER N65-20177

OPTICAL RANGEFINDER USING GALLIUM ARSENIDE LASER  
AS TRANSMITTER AND SILICON P-I-N PHOTODIODE AS  
DETECTOR USED AS AIRCRAFT ALTITUDE METER N66-11665

**HAMMEL, J. E.**  
PLASMA INTERFEROMETRY TECHNIQUE WHERE REFLECTED-  
BACK OUTPUT OF GAS LASER IS MODULATED, USING PHASE  
VARIATIONS A65-19754

**HAMMER, J. M.**  
ELECTRON BEAM PUMPING OF NOBLE GAS ION LASER  
A66-10350

**HANCE, H. V.**  
WIDEBAND LASER BEAM MODULATION, USING BRAGG-  
ANGLE DIFFRACTION BY AMPLITUDE-MODULATED  
ULTRASONIC WAVES A65-29974

**HANES, G. R.**  
SIMPLE SINGLE MODE HELIUM-NEON LASER WHOSE OUTPUT  
IS SUFFICIENT FOR INTERFEROMETRIC METROLOGY  
A65-22621

**HANG, C.**  
SEPARATION OF SINGLE WAVE OSCILLATION MODES OF  
NEON-HELIUM GAS LASER N65-20782

**HANKIN, R. B.**  
HIGH SENSITIVITY FAST-RESPONSE LASER DETECTION  
SYSTEM, DESCRIBING MICROWAVE RESPONSE  
PHOTOELECTRIC DETECTOR WITH AMPLIFICATION AND  
MIXING FUNCTIONS A66-22046

**HARADA, R. H.**  
INJECTION DIODE LASER FROM DEGENERATED GALLIUM  
ARSENIDE WITH NEODYMIUM DOPED LAYER EMITTING AT  
8700 ANGSTROMS A65-15995

**HARBURN, G.**  
CONTINUOUS OUTPUT GAS-PHASE LASERS AS SMALL  
BANDWIDTH SOURCES OF LIGHT FOR OPTICAL  
DIFFRACTOMETERS A65-22206

**HARDING, G. D.**  
OPTIMIZING FLASH LAMPS FOR PUMPING LASER RODS  
BY MEANS OF DOPING AD-613346 N65-25890

**HARDWAY, G. A.**  
LASER BEAM MACHINING AND DRILLING TECHNIQUES FOR  
USE ON ANY MATERIAL REGARDLESS OF THERMAL  
PROPERTIES A65-25373

**HARDY, W. A.**  
OPTICAL CAVITY IN WHICH MODES ARE DETERMINED AS  
STATIONARY STATES OF DIFFRACTION-LIMITED OBJECT/  
IMAGE TRANSFORMATION OF CLASSICAL OPTICS A65-18013

**HARGROVE, L. E.**  
LIGHT OUTPUT FROM HELIUM-NEON GAS MASER  
PHOTOGRAPHED WITH AND WITHOUT INTRACAVITY  
MODULATION AT LOCKING FREQUENCY, USING HIGH SPEED  
ROTATING MIRROR A66-17205

**HARRIS, S. E.**  
LASER OSCILLATION WHEREIN LASER MODES OSCILLATE  
WITH APPROXIMATELY FM PHASES THEREBY COMPRISING  
SIDEBANDS OF FM LIGHT SIGNAL A65-21876

CONTROLLING FM AND SUPERMODE LASER OUTPUT  
FREQUENCIES BY THRESHOLD CONTROL AND  
INTERFEROMETRIC CONTROL A65-36842

CARRIER FREQUENCY STABILIZATION OF FM LASER WITH  
RESPECT TO CENTER OF ATOMIC GAIN PROFILE, USING  
SMALL DISTORTION PRESENT IN LASER OSCILLATION  
A66-10966

F M LASER OSCILLATION THEORY DISCUSSING EFFECT OF  
ARBITRARY ATOMIC LINE SHAPE, SATURATION, MODE  
PULLING, POWER OUTPUT, SIDE BAND AMPLITUDE,  
DISTORTION, ETC A66-13954

FREQUENCY-SELECTIVE TRANSMISSION ETALON REPLACES  
END MIRROR OF FM LASER SO THAT TOTAL POWER IS  
OBTAINED AS SINGLE OPTICAL FREQUENCY A66-16381

PROPERTIES OF FREQUENCY MODULATION AND SUPER MODE  
LASER IER-1 N66-10766

EXPERIMENTAL AND THEORETICAL PROGRAM TO DETERMINE  
FUNDAMENTAL PROPERTIES OF FREQUENCY MODULATION  
AND SUPER-MODE LASERS IER-2 N66-21405

**HARTMAN, P. L.**  
EXCITED STATE SPECTROSCOPY USING RUBY LASER AND  
LOCALIZED EXCITONS IN ALKALI HALIDES AD-619198 N65-35423

**HARTMANN, S. R.**  
PHOTON ECHO, SHORT PULSE OF LIGHT SPONTANEOUSLY  
EMITTED BY DILUTE RUBY CRYSTAL AFTER RUBY-LASER  
PULSE IRRADIATION A66-18442

**HAUCHECORNE, G.**  
MOLECULAR ANISOTROPY OF PROPAGATION OF INTENSE  
LIGHT BEAM, NOTING RAMAN AND BRILLOUIN EFFECTS  
A66-15106

**HAUGHT, A. F.**  
MECHANISMS ASSOCIATED WITH ELECTRICAL BREAKDOWN  
AND IONIZATION IN GAS CAUSED BY HIGH INTENSITY  
RUBY OR NEODYMIUM LASER ILLUMINATION D-920272-4 N66-11453

RUBY LASERS USED IN STUDYING PHYSICAL PROCESSES  
LEADING TO IONIZATION OF GASES BY INTENSE  
OPTICAL RADIATION UACRL-E920272-6 N66-20600

**HAUS, H. A.**  
AMPLITUDE NOISE MEASUREMENT FOR CAVITY TYPE  
GASEOUS OPTICAL MASER OSCILLATOR ABOVE AND BELOW  
THRESHOLD A65-19544

AMPLITUDE NOISE ANALYSIS OF MASER OSCILLATOR,  
USING VAN DER POL EQUIVALENT CIRCUIT A65-33375

BRILLOUIN SCATTERING OF LIGHT BY PHONONS AND  
PHONON MASER IN DERIVATION OF CONSERVATION  
THEOREMS FROM BASIC EQUATIONS A66-18397

ANODE-CURRENT SPECTRUM OF PHOTOMULTIPLIER  
ILLUMINATED BY LIGHT OF TIME-VARYING INTENSITY AND  
DERIVATION OF MOMENTS OF PHOTOELECTRON COUNTS  
A66-18432



- HAYASAKA, S.**  
HIGH POWER RELAXATION OSCILLATION IN MULTILEVEL  
SOLID STATE RUBY MASER DUE TO MAGNETIC FIELD  
MODULATION A66-13327
- HAYASHI, R.**  
CHROMIUM-DOPED RUTILE MASER INVERSION RATIO CROSS  
RELAXATION EFFECT OPERATING AT LIQUID NITROGEN  
TEMPERATURES A65-23385
- HAYES, M. D., JR.**  
LASER SOURCE REFLECTOMETER TO MEASURE REFLECTANCE  
OF SPECIMENS AT HIGH TEMPERATURE - RELATION OF  
THERMAL EMISSION TO OTHER OPTICAL PROPERTIES  
NBS-TN-267 N66-22418
- HEAVENS, O. S.**  
LASER APPLICATION AND TECHNIQUES NOTING  
AMPLIFICATION, MODULATION, INTERFEROMETRY,  
SCATTERING, PLASMA DIAGNOSTICS, NONLINEAR OPTICS,  
ETC A66-23931
- HEER, C. V.**  
REFLECTION COEFFICIENT OF CAVITY TUBING AS  
EXPLANATION FOR POWER LEVEL OF HELIUM-NEON IR  
FABRY-PEROT INTERFEROMETER A65-30342
- MODEL FOR BEHAVIOR OF OPTICAL MASER IN STATIC  
MAGNETIC FIELD OF ARBITRARY STRENGTH IN Z  
DIRECTION AND IN ELECTROMAGNETIC FIELD COMPOSED OF  
TRAVELING WAVES A66-13135**
- HEFLINGER, L. O.**  
HIGH SPEED PHENOMENA HOLOGRAMS PRODUCED BY  
RADIATION FROM PULSED RUBY LASER OPERATED EITHER  
IN Q-SWITCHED OR CONVENTIONAL MODE A65-35067
- HEIL, M.**  
ELECTRON ENERGY SPECTRA IN NEON, XENON AND HELIUM-  
NEON LASER DISCHARGES, CALCULATING PRODUCTION AND  
DESTRUCTION RATE PARAMETERS A66-18354
- HEIMDL, R.**  
PREPARATION OF SINGLE CRYSTALS OF DOUBLE  
MOLYBDATES OF NA AND LA /OR OTHER RARE EARTH  
ELEMENTS/ DOPED WITH ND, TB OR PR FOR LASER  
APPLICATION A66-13478
- HEINEMANN, H. M.**  
MODE IMPURITY OBSERVED IN DIFFRACTION MEASUREMENTS  
EMPLOYING GAS LASER APPARENTLY RESONATING IN  
TEM-00 MODE A65-16571
- OPTICAL SIMULATION OF MICROWAVE ANTENNAS WITHOUT  
DIRECT FREQUENCY SCALING, OBTAINING AMPLITUDE  
DISTRIBUTION OF LASER RADIATION FIELDS A65-29418**
- FEASIBILITY OF SINGLE-MODE MACROSCOPIC OPTICAL  
WAVEGUIDES AND COMPONENTS OPERATING AT  
MICROWAVE FREQUENCIES FOR ADVANCED LASER  
SYSTEMS NASA-CR-60527 N65-16252**
- MACROSCOPIC WAVEGUIDE AND WAVEGUIDE COMPONENTS FOR  
OPTICAL SYSTEMS - LASERS NASA-CR-332 N66-16086**
- HEINLEIN, W.**  
MODES OF EMISSION-VS-TIME SPECTRUM, OPTICAL  
EMISSION SPECTRUM AND SUPERPOSITION SPECTRUM OF  
SHORT CONFOCAL RUBY LASER IN NEAR FIELD A66-14290
- HEINZ, W.**  
DEVELOPMENT AND APPLICATION OF IMPROVED MASER  
TECHNIQUES FOR BROADBAND MASER SYSTEM -  
TRAVELING WAVE MASER TECHNIQUES RADC-TR-65-148 N65-32203
- HEINZ, W. W.**  
SOLID STATE AND MASER TECHNIQUES - BREADBOARD  
EVALUATION, MEASUREMENTS OF LOW-TEMPERATURE  
SEMICONDUCTOR, AND SUPERCONDUCTING THIN FILM  
TUNNELING EFFECTS RADC-TDR-64-480 N65-16017
- SOLID-STATE AND TRAVELING-WAVE MASER TECHNIQUES**
- RADC-TR-65-30 N65-33397**
- BROADBAND TRAVELING WAVE MASER TECHNIQUES AND  
N-TYPE GERMANIUM SEMICONDUCTOR DEVELOPMENT  
RADC-TR-65-366 N66-15720**
- HEISE, B. M.**  
RUBY GROWTH PROCESS FOR RANGEFINDER LASER RODS  
QPR-1 N66-19918
- HELLER, M. E.**  
ABSORPTION DATA FOR METHANE AND ETHANE, USING HE-  
NE TUNED LASER SPECTROSCOPY A65-20064
- HELLER, Z. M.**  
SIMULTANEOUS LASER OSCILLATION OBSERVED AT 6943  
AND 6929 ANGSTROM WAVELENGTHS IN NORMAL AND Q-  
SPOILED OPERATION OF RUBY LASER A65-32748
- HELLMARTH, R. W.**  
GIANT PULSE LASER APPLIED TO NONLINEAR OPTICAL  
EFFECT OF STIMULATED RAMAN SCATTERING WITH  
REFERENCE TO EMISSION ANGLE MEASUREMENT TECHNIQUE  
A65-19996
- HENKEL, H. J.**  
GALLIUM ARSENIDE LASER DIODES BEHAVIOR AT HIGH  
PULSE RADIATION LOADS A65-29356
- HENNEBERGER, M. C.**  
VARIATION OF SCATTERING CROSS SECTION WITH BEAM  
INTENSITY FOR RUBY LASER LIGHT ON ATOMIC HYDROGEN  
A66-15864
- HENRY, H. E.**  
MEASUREMENTS AND LIMITATIONS OF ATMOSPHERIC  
EFFECTS ON LASER PROPAGATION FOR SPACE  
COMMUNICATION NASA-CR-67382 N65-35846
- HENSEL, M. L.**  
COHERENT HIGH POWER PULSES FROM OPTICALLY PUMPED  
Y A G-ND LASER BY Q-SWITCHING FROM MIRROR  
ROTATION A65-26003
- HEPNER, G.**  
PHOTOELECTRONS EMITTED BY PHOTOCATHODE LIT BY HEAT  
SOURCE AND LASER COUNTING NUMBER OF AVALANCHES  
DURING GIVEN TIME A65-18037
- HERCHER, M.**  
SINGLE AXIAL MODE OPERATION OF RUBY LASER AT ROOM  
TEMPERATURE, USING SATURABLE FILTER Q-SWITCH AND  
RESONANT REFLECTOR A65-29852
- TRAVELING WAVE OSCILLATIONS IN RUBY LASER  
RESONATOR USING PASSIVE OPTICAL ISOLATOR,  
ELIMINATING FARADAY ROTATOR AND ATTENDANT  
MAGNETIC FIELD A66-11448**
- HERCHER, M. M.**  
TIME RESOLVED INTERFEROMETRY, CINEMATOGRAPHY, AND  
TRAVELING WAVE CAVITY STUDIES ON RUBY LASERS  
AFCL-65-467 N66-16656
- RUBY LASER RADIATION INTENSITY DISTRIBUTIONS BY  
HIGH SPEED CINEMATOGRAPHY AND TIME RESOLVED  
INTERFEROMETRY FOR PUMPED RADIATION EFFECTS  
N66-16657**
- HERGENROTHER, K. M.**  
STORAGE DIODE LASER RESEARCH  
AD-618297 N65-34108
- HERMAN, M.**  
MAGNETIC Q-FACTOR DESCRIBING ELECTROMAGNETIC  
FIELD ENERGY LOSSES IN PARAMAGNETIC MASER  
CRYSTALS A65-26860
- HERMANCE, J.**  
RUBY AS SUBMILLIMETER MASER MATERIAL, NOTING  
RELAXATION TIME AND TEMPERATURE CRITERIA  
A65-26821
- HERSCHBACH, D. R.**  
ATOMIC AND MOLECULAR FLUORESCENCE EXCITED BY  
PHOTODISSOCIATION, DISCUSSING LINE STRENGTH AND  
DOPPLER WIDTH A65-20073

- HERZIGER, G.**  
HELIUM-NEON GAS DISCHARGE INTENSIFICATION FOR  
6328 Å LASER WAVELENGTH, DISCUSSING MEASUREMENT  
TECHNIQUES, GAIN PARAMETERS AND RESULTS A66-18632
- HEUMANN, F. K.**  
SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION,  
CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION,  
FREQUENCY MODULATION LASERS, AND GALLIUM  
COMPOUND INGOTS FOR LASER APPLICATION  
AFCRL-64-1007 N65-23135
- GALLIUM ARSENIDE ALLOY INGOT PREPARATION BY  
VAPOR TRANSPORT METHODS FOR LASER APPLICATIONS  
N65-23139
- HEYNAU, H. A.**  
OPTICALLY BIASED PULSED TRANSMISSION MODE  
OPERATION OF Q-SWITCHED LASER, IN CONNECTION WITH  
KERR CELLS INHIBITING LASING ACTION A66-19937
- HIBBEN, S. G.**  
MULTICAVITY RADIOMETER MASERS FOR RECORDING 21 CM  
EMISSION FROM GALACTIC HYDROGEN N65-18885
- HIGA, W. H.**  
TRAVELING WAVE MASER FOR DIRECT MEASUREMENT OF  
CHANGES IN RUBY SPIN TEMPERATURE FOR VARIOUS  
PERTURBATIONS NASA-CR-58815 N65-29444
- HILL, D.**  
DIRECT-INDIRECT TRANSITION EFFECT ON HALL EFFECT  
IN GALLIUM /ARSENIC PHOSPHIDE/ A66-21570
- HILL, H.**  
PULSED WATER VAPOR LASER FOR FAR IR GIVING DESIGN  
AND PERFORMANCE A65-22626
- PULSED GAS LASER FOR FAR INFRARED REGION OF  
SPECTRUM N65-20170
- HIOKI, R.**  
FRAUNHOFER PATTERN OF LASER LIGHT TRANSMITTED  
THROUGH OPTICAL FIBER, NOTING SPATIAL FREQUENCY OF  
INTERFERENCE FRINGES BETWEEN LIGHT WAVES A66-14972
- HIRAYAMA, C.**  
LASER OSCILLATION INCREASE IN EFFICIENCY IN  
NEODYMIUM DOPED GLASS PRODUCED THROUGH ENERGY  
TRANSFER A66-10352
- HIROMO, M.**  
OPTICAL RADAR OBSERVATION OF UPPER ATMOSPHERIC  
CONSTITUENTS BY LASER BEAMS, EXAMINING NEW METHODS  
BY RESONANCE SCATTERING OF VARIOUS WAVELENGTHS  
A65-14683
- UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE  
RUBY LASER TECHNIQUES, PRESENTING HEIGHT  
DISTRIBUTION CURVES OF SCATTERED LIGHT A66-13376
- HIRSHFIELD, J. L.**  
INTERACTION OF ENERGETIC ELECTRONS WITH BOUNDED  
ELECTROMAGNETIC WAVES NEAR CYCLOTRON RESONANCE,  
NOTING PLASMA DIAGNOSTICS, MASER AND GAIN  
MECHANISM A66-13953
- HO, Y.-P.**  
THREE-LEVEL LASER OUTPUT STABILITY EQUATION  
DERIVED BY NONLINEAR MECHANICS, NOTING LIMIT CYCLE  
AND OSCILLATION STABILITY PRECONDITION A65-17514
- EQUATIONS OBTAINED FROM HAMILTONIAN FOR COUPLING,  
FIRST STOKES LINE, FIRST ANTI-STOKES LINE AND  
COHERENT FIELD FOR RAMAN LASER A66-22490
- HOCHSTADT, H.**  
EIGENVALUES OF INTEGRAL EQUATIONS IN LASER  
RESONANT CAVITIES A66-21343
- HOCHULI, U.**  
ALUMINUM COLD CATHODES WITH SINGLE MODE  
6328 Å LASER WAVELENGTH, DISCUSSING MEASUREMENT  
EXCEEDING 3000 HOURS A66-10855
- HODARA, H.**  
STATISTICS OF MULTIMODE LASER SIGNALS DERIVED AND  
COMPARED WITH THOSE OF INCOHERENT RADIATION A65-31034
- HODGES, E.**  
ISOTOPE SHIFT, LINEWIDTH AND PRECISE WAVELENGTH OF  
LASER EMISSION IN IONIZED HG A66-18035
- HOENNE, M. E.**  
LASER RADAR AS INSTRUMENT TO OBTAIN OPERATIONAL  
METEOROLOGICAL INFORMATION A66-21067
- HOGBERG, L.**  
EFFECT OF LASER IRRADIATION ON INNER EAR IN  
PIGEONS A66-80961
- HOGG, D. C.**  
HE-NE LASER IR RADIATION EMISSION ATTENUATED BY  
ATMOSPHERIC METHANE A66-23090
- HOLLIDAY, D.**  
QUANTUM STATISTICAL PROCEDURE DEVELOPED FOR  
RADIATION FIELD AND APPLIED TO LASER AMPLIFIERS  
A65-32707
- QUANTUM STATISTICS FOR ANALYZING RADIATION FIELDS  
INTERACTING WITH OTHER SYSTEMS APPLIED TO MODEL  
LASER OPERATING AS LINEAR AMPLIFIER A66-13260
- QUANTUM AND CLASSICAL MECHANICAL THEORIES OF LASER  
RADIATION RM-4435-PR N65-19297
- QUANTUM STATISTICAL PROCEDURE FOR STUDYING  
INTERACTING RADIATION FIELD APPLIED TO MODEL  
LASER OPERATING AS LINEAR AMPLIFIER RM-4516-PR N65-27655
- HOLLOWAY, J.**  
HYDROGEN MASER AND CESIUM BEAM TUBE FREQUENCY  
STANDARDS COMPARED A65-16680
- HOLMES, S. J.**  
MICA OPTICAL INTERFERENCE FILTERS FOR SELECTED  
LASER FREQUENCIES AD-466027 N65-28608
- HOLONYAK, M., JR.**  
DIRECT-INDIRECT TRANSITION EFFECT ON HALL EFFECT  
IN GALLIUM /ARSENIC PHOSPHIDE/ A66-21570
- GROWTH OF GALLIUM ARSENIDE-PHOSPHIDE COMPOUNDS  
FOR LASER USE AFCRL-65-271 N65-27833
- ZINC DIFFUSION IN GALLIUM ARSENIDE-PHOSPHIDE  
LASERS AND EFFECTS ON SEMICONDUCTOR JUNCTIONS  
AFCRL-66-18 N66-22611
- HOLZAPFEL, W.**  
HELIUM-NEON GAS DISCHARGE INTENSIFICATION FOR  
6328 Å LASER WAVELENGTH, DISCUSSING MEASUREMENT  
TECHNIQUES, GAIN PARAMETERS AND RESULTS A66-18632
- HOOPER, E. B., JR.**  
LASER INTERFEROMETER TO MEASURE TIME AND SPATIAL  
VARIATION IN REPETITIVELY PULSED PLASMA A66-10243
- HORA, H.**  
ABSORPTION COEFFICIENT OF RUBY LASER RADIATION  
IN FULLY IONIZED LIGHT ELEMENTS IPP-6/27 N65-30178
- ESTIMATION OF PLASMA HEATING BY LASERS  
NRC-TT-1193 N66-10962
- PLASMAS HEATED BY LASERS TO TEMPERATURES OF  
INTEREST TO THERMONUCLEAR CONDITIONS PRODUCE  
NONRESONANT IONIZATION NRC-TT-1193 N66-17933

- MOROVIX, A.**  
RUBY LASER FIELD PATTERNS - DIFFRACTION PATTERNS  
TR-1 N65-22896
- MORI, T.**  
DESIGN OF 8 MILLIMETER TRAVELING WAVE MASER  
FOR RADIO ASTRONOMY  
AD-619191 N65-35172
- MORRIGAN, F.**  
EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASERS  
S-705 N65-15980
- GAS LASERS - LEVEL POPULATION DEPENDENCES, LASER  
POWER OUTPUT, METASTABLE DENSITY MEASUREMENTS,  
AND PARAMETER CHANGE EFFECT ON MATHEMATICAL  
MODEL OF LASER SYSTEM  
S-740 N65-20002
- EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASER, XENON LIFETIMES, AND THEORY OF  
DIFFUSION CONTROLLED GLOW DISCHARGE  
S-669 N65-28779
- MORRIGAN, F. A.**  
I R LASER ACTION IN ARGON II BETWEEN 1 AND 2  
MICRONS AND IN 6000 TO 7000 ANGSTROM RANGE  
A65-17207
- TRANSITION PROBABILITIES FOR AR II LASER LINES  
COMPARED WITH PREVIOUS THEORETICAL AND  
EXPERIMENTAL DATA  
A65-29799
- MORRATH, R. S.**  
POWER OUTPUT AND THRESHOLD POWER FOR CONTINUOUS  
WAVE NEODYMIUM-CALCIUM TUNGSTATE LASER IN RANGE OF  
DRY ICE TO ROOM TEMPERATURE  
A65-22619
- MOSHI, T.**  
LASER WELDING EVALUATED WITH REGARD TO PERFORMANCE  
AND PRODUCTION APPLICATION  
A66-14692
- MOSKINS, R. H.**  
PULSED AND CONTINUOUS WAVE LASER OPERATION OF  
THULIUM ION DOPED ERBIUM OXIDE WHICH PROVIDES  
PUMPING MECHANISM BY MEANS OF ENERGY TRANSFER  
A65-26955
- IMPROVEMENT OF CRYSTAL QUALITY OF FLAME FUSION  
RUBY - LASER MATERIAL  
AL-TDR-64-195, PT. I N65-15848
- SOLID STATE LASER AMPLIFIER STRUCTURES  
QPR-8 N66-12048
- PULSED YTTRIUM-ALUMINUM GARNET NEODYMIUM LASER  
DEVICE - SOLID STATE LASER DEVICE  
QPR-9 N66-14725
- MOTZ, D. F.**  
SINGLE-ATOM COHERENCE EFFECTS IN MEASUREMENT OF  
SPONTANEOUS EMISSION LINewidths IN HIGH-GAIN NEON  
LASER  
A65-21654
- GAIN NARROWING OF INHOMOGENEOUSLY BROADENED LINE  
IN STIMULATED EMISSION IN LASER AMPLIFIER  
A65-22615
- HOWARD, R. H., JR.**  
RESONANT ENERGY TRANSFER FROM MERCURY TO ZINC IN  
GAS LASER  
AD-603680 N65-14200
- HOME, J. A.**  
LASER ACTION ON P- AND R-BRANCH TRANSITIONS OF  
CARBON DIOXIDE VIBRATIONAL SPECTRUM BAND PRODUCED  
BY PULSED DISCHARGE ADMIXTURE OF VARIOUS GASES  
A65-33058
- HOZUMI, H.**  
OBSERVATIONS OF RADIO SOURCES AT 9.4 GC WITH 2.2  
FOOT FAN BEAM OF 16-ELEMENT INTERFEROMETER AND  
MASER AMPLIFIER  
A65-28335
- HRIVNAK, G. A.**  
MICROMINIATURIZED ELECTRONIC LASER RANGE COUNTER  
SOLID STATE DEVICE  
ECOM-2543 N66-15212
- HSI, C.**  
OPTICAL MASER OF TRIVALENT NEODYMIUM IN TUNGSTATE  
CRYSTALS  
N66-15045
- HSIA, C.-L.**  
FORMATION TIME OF OPTICAL LASER OSCILLATIONS  
N66-15050
- HSIEH, H.-Y.**  
FORMATION OF MICROWAVE MASER BY PUMPING OF LOW  
TEMPERATURE RUBY LASER  
N66-15049
- HSING, C.**  
STIMULATED EMISSION OF LIGHT FROM PURE XENON AND  
HELIUM-XENON  
N65-20135
- HELIUM-NEON LASER WITH SILVER AND DIELECTRIC  
COATING  
N65-20136
- HSU, H.**  
FORWARD TRAVELING COHERENT ACOUSTIC WAVE AND  
BACKWARD TRAVELING ELECTROMAGNETIC WAVE PRODUCED  
IN STIMULATED BRILLOUIN SCATTERING OF INTENSE  
LASER BEAM  
A65-32745
- HUANG, F.-H.**  
STIMULATED EMISSION OF LIGHT FROM PURE XENON AND  
HELIUM-XENON  
N65-20135
- HELIUM-NEON LASER WITH SILVER AND DIELECTRIC  
COATING  
N65-20136
- HUANG, W.-H.**  
FORMATION OF MICROWAVE MASER BY PUMPING OF LOW  
TEMPERATURE RUBY LASER  
N66-15049
- HUANG, Y.-K.**  
OPTICAL MASER OF TRIVALENT NEODYMIUM IN TUNGSTATE  
CRYSTALS  
N66-15045
- HUBACH, R. A.**  
ELECTRON ENERGY SPECTRA IN GAS LASER DISCHARGES  
AND INVESTIGATION OF NEW DISCHARGE  
CONFIGURATIONS  
NASA-CR-67298 N65-35355
- HUDSON, J. E.**  
OPTICAL LASER PUMPS, HIGH POWER CW LASER  
OPERATION BY CATHODOLUMINESCENCE AND SUITABLE  
SELECTION OF PHOSPHORS  
A66-19546
- HUDSON, O. K.**  
METEOROID SIMULATION USING LASERS  
NASA-TM-X-53122 N65-17872
- HUEN, T.**  
LASER BEAM DEFLECTION MODULATION OBTAINED BY  
PASSING CURRENT THROUGH CADMIUM SULFIDE PRISM WITH  
OHMIC CONTACTS, USED FOR THERMOCOUPLE MEASUREMENTS  
A65-25890
- HUFFAKER, R. M.**  
CONTINUOUS WAVE GAS LASER DOPPLER FLOW METER FOR  
GAS VELOCITY MEASUREMENT  
N66-22338
- HUGHES, W. E.**  
ALUMINUM NITRATE POWDER MASER DOPED WITH FERRIC  
IONS OPERATION IN X-BAND WITHOUT EXTERNAL DC  
MAGNETIC FIELD  
A66-11374
- MILLIMETER AND SUBMILLIMETER MASER DEVICES  
ITR-5 N65-14383
- ZERO FIELD X-BAND MASER DESIGN FOR MICROWAVE  
QUANTUM AMPLIFIERS - MILLIMETER AND  
SUBMILLIMETER WAVE DEVICES  
REPT.-490F N65-25851
- MILLIMETER AND SUBMILLIMETER MASER DEVICES -  
MEASURING TECHNIQUES FOR ZERO FIELD MASER  
REPT.-490G N65-33895
- MILLIMETER AND SUBMILLIMETER MASER DEVICES - IRON-  
DOPED MASER AMPLIFIER, PUSH-PULL RUTILE MASEB,  
AND X-BAND ZERO FIELD MASERS  
REPT.-490H N66-16210
- HULL, G. F., JR.**  
CHROMIUM ALIGNMENT IN RUBY BY OPTICALLY PUMPING

- RUBY SAMPLE WITH CIRCULAR POLARIZED RADIATION FROM RUBY LASER A65-33418
- HUMPHREYS, C. J.**  
RESEARCH REPORTS ON CODER COMPONENTS, POLYMERS, SPECTROSCOPY, LASERS, ELECTROCHEMISTRY, TRANSMISSION LINES, AND SEMICONDUCTOR PHYSICS NAVWEPS-8150 N65-15565
- RESEARCH IN FERROMAGNETISM, POLYMER CHEMISTRY, LASERS, SEMICONDUCTORS, AND SOLID STATE SPECTROSCOPY NAVWEPS-8226 N65-26765
- HUNTLEY, W. M., JR.**  
DEVELOPMENT IN U.S. OF LASER APPLICATION WITH TABLE INCLUDING GOVERNMENT SUPPORTED PROGRAMS IN PHOTOGRAPHY, DATA PROCESSING, RADAR, ETC A66-11455
- HURLEY, J. W.**  
RUBY LASER CRYSTALS GROWN BY FLAME-FUSION, FLUX AND CZOCHRALSKI METHOD EXAMINED FOR PERFECTION BY X-RAY TOPOGRAPHY AND DOUBLE-CRYSTAL ROCKING CURVES A66-13744
- HURST, S. R.**  
LASER RANGING EXPERIMENTS PERFORMED WITH BEACON EXPLORER B A65-21303
- HURWITZ, C. E.**  
LASER ACTION AT LIQUID HELIUM TEMPERATURE IN CRYSTALS OF LEAD SAMARIUM, LEAD SELENIDE AND LEAD TELLURIDE EXCITED BY FAST ELECTRON BEAM A65-30346
- I
- IAKUBOVICH, E. I.**  
LASER OSCILLATION AND ENERGY LOSSES IN MEDIUM CONTAINING ACTIVE MOLECULES A65-24811
- PERIODIC AUTOMODULATION OF RADIATION AND POSSIBILITY OF GENERATING GIANT PULSES IN THREE-LEVEL LASER WITH INHOMOGENEOUSLY EXCITED ACTIVE MEDIUM A66-11842
- IANNINI, A. A.**  
FABRY-PEROT GALLIUM ARSENIDE LASER HIGHER ORDER AXIAL MODE TEMPERATURE DEPENDENCE A65-17655
- IANNUZZI, M.**  
TIME CORRELATION BETWEEN LASER PULSES AND LASER-INDUCED ELECTRON EMISSION FROM METALLIC SURFACES A65-34616
- IATSENKO, D. F.**  
RADIATION FLUCTUATIONS IN LASER PULSE REGIME, DISCUSSING ERRORS ARISING IN COMPARING BASIC WITH SECONDARY EMISSION A65-14617
- ICHINOSE, M.**  
UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE RUBY LASER TECHNIQUES, PRESENTING HEIGHT DISTRIBUTION CURVES OF SCATTERED LIGHT A66-13376
- IGARASHI, T.**  
CHROMIUM-DOPED RUTILE MASER INVERSION RATIO CROSS RELAXATION EFFECT OPERATING AT LIQUID NITROGEN TEMPERATURES A65-23385
- UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE RUBY LASER TECHNIQUES, PRESENTING HEIGHT DISTRIBUTION CURVES OF SCATTERED LIGHT A66-13376
- GROUND STATE ESR SATURATION EFFECT ON RUBY LASER OUTPUT FREQUENCY AT CRYOGENIC TEMPERATURE A66-16753
- IJIMA, S.**  
GENERAL PROGRESS OF SEMICONDUCTOR JUNCTION AND RUBY LASERS, ESPECIALLY IN EXPERIMENTAL FIELD A66-11370
- ILIFF, R. L.**  
OPTICAL TRACKING OF SATELLITES EQUIPPED FOR
- GEODETIC TRIANGULATION, USING GROUND LASER BEAMS A65-29936
- ILIN, V. V.**  
AMMONIA MASER - AMMONIA MOLECULAR GENERATOR FTD-TT-65-803/16264 N66-19855
- ILINOVA, T. M.**  
NONLINEAR PROPAGATION OF PULSE SIGNAL IN LASER TYPE TRAVELING WAVE AMPLIFIER A66-11841
- IMAGAMA, H.**  
FAR FIELD PATTERNS OF OFF-AXIAL MODES IN CYLINDRICAL GLASS NEODYMIUM LASER RODS A65-34807
- INABA, H.**  
OBSERVATIONS OF RADIO SOURCES AT 9.4 GC WITH 2.2 FOOT FAN BEAM OF 16-ELEMENT INTERFEROMETER AND MASER AMPLIFIER A65-28335
- HIGH POWER RELAXATION OSCILLATION IN MULTILEVEL SOLID STATE RUBY MASER DUE TO MAGNETIC FIELD MODULATION A66-13327
- INGALLS, A.**  
COHERENT TRANSFER CHARACTERISTICS OF OPTICAL SYSTEM, HOLOGRAMS AND COMPLEX SPATIAL FILTERS, AND LASER APPLICATIONS C-5210-72-T80-110 N65-21691
- INGALLS, A. L.**  
MICROWAVE ANTENNA SIMULATION AT OPTICAL FREQUENCY, USING NEON-HELIUM CONTINUOUS GAS LASER A66-22539
- INUISHI, Y.**  
FLUORESCENCE FROM CADMIUM SULFIDE EXCITED BY RUBY LASER COMPARED WITH PHOTOCONDUCTIVITY INDUCED BY ORDINARY GREEN LIGHT TO SUPPORT DOUBLE PHOTON ABSORPTION MECHANISM A65-34665
- SHIFT OF EMISSION SPECTRUM IN PULSED GA AS LASER, NOTING WAVEFORM CHARACTERISTICS A66-14974
- RADIATION DAMAGE AND ANNEALING OF GALLIUM ARSENIDE LASER DIODE A66-14979
- IRVING, J.**  
ELECTRON DENSITY MEASUREMENTS IN PLASMA PRODUCED BY COMBINATION OF RF AND VERY FAST THETA-PINCH DISCHARGES, USING GAS LASER INTERFEROMETER A65-29848
- TIME-DEPENDENT ELECTRON DENSITY VARIATION STUDIED IN FAST THETA-PINCH DISCHARGE, USING HE-NE GAS LASER INTERFEROMETER A65-29849
- ISAENKO, V. I.**  
EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS BY INCLINING GENERATING SAMPLE WITH RESPECT TO INTERFEROMETER AXIS A65-18454
- EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS BY INCLINING GENERATING SAMPLE WITH RESPECT TO INTERFEROMETER AXIS A65-28083
- THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE LOSSES IN FABRY-PEROT RESONATORS DUE TO MIRROR MISALIGNMENT A65-36053
- THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE LOSSES IN FABRY-PEROT RESONATORS DUE TO MIRROR MISALIGNMENT A66-15856
- ISENOR, N. R.**  
BACKGROUND GAS PRESSURE EFFECT ON LASER INDUCED ELECTRON EMISSION FROM ZINC AND TANTALUM SURFACES A65-15838
- ISHIDA, T.**  
UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE RUBY LASER TECHNIQUES, PRESENTING HEIGHT DISTRIBUTION CURVES OF SCATTERED LIGHT A66-13376
- ITZKAN, I.**  
REQUIREMENTS FOR GENERATING TRULY CIRCULAR MODE OF

- OSCILLATION IN GAS LASER SYSTEM  
A65-19602
- ISOLATION OF 1.0621 LINE IN HE- NE GAS LASER BY  
MULTILAYER DIELECTRIC-COATED MIRRORS WITH SHARP  
SPECTRAL CUT-OFF CHARACTERISTICS  
A66-20517
- IVANOVICH, A. E.  
GALLIUM ARSENIDE LUMINESCENT DIODES WITH  
TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION  
AT HIGH DENSITY CURRENT  
A65-36787
- GALLIUM ARSENIDE LUMINESCENT DIODES WITH  
TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION  
AT HIGH DENSITY CURRENT  
A66-19195
- LASER CRYSTALS PREPARED ECONOMICALLY BY SPLITTING  
ALONG CLEAVAGE PLANES  
A66-23293
- IVANOV, V. S.  
SEMICONDUCTOR-BASED PULSE GENERATOR FOR LASER  
EXCITATION  
A66-11042
- SEMICONDUCTOR-BASED PULSE GENERATOR FOR LASER  
EXCITATION  
A66-23289
- IMAI, Y.  
RADIATIVE TRANSITION PROCESS IN EMISSION SPECTRUM  
OF GALLIUM ARSENIDE P-N JUNCTION LASER DIODES  
A65-34666
- IZATT, J. R.  
REFRACTIVE INDEX VARIATION DURING LASER OPERATION  
AND CAST-PLASTIC OPTICAL-PUMP CAVITY EQUIPMENT  
FOR PUMPING AND TEMPERATURE CONTROL DURING  
EXPERIMENT  
SATR-1  
N65-15753
- EFFECT OF OPTICAL PUMPING ON ANOMALOUS DISPERSION  
IN SELECTED RUBY LASERS AND VARIATION OF  
REFRACTIVE INDEX DURING LASER OPERATION  
SATR-3  
N65-28619
- JACKSON, D. W.  
LASER APPLICATION PROBLEMS IN INTERFEROMETRY,  
RADAR AND HOLOGRAPHY INCLUDING MECHANICAL  
STABILITY, NOISE SUPPRESSION, DIRTY LASER BEAM  
RESTORATION, ETC  
A66-11454
- JACKSON, J. E.  
PULSED LASER WELDING, WIRE-TO-WIRE, SHEET-TO-  
SHEET, CIRCUIT BOARD, VACUUM TUBE, ETC  
A66-18153
- JACKSON, R. A.  
GAS LASER AS LIGHT SOURCE FOR MACH ZEHNDER  
INTERFEROMETER AS COMPARED TO MERCURY VAPOR LAMP  
A65-22949
- JACKSON, R. E.  
APPARATUS FOR FLUORIDATION OF HYDROXYL AND OXYGEN  
CONTAMINATED FLUORIDE COMPOUNDS, OBTAINING  
OPTICALLY CLEAR CRYSTALS WITH NO TYNDALL  
SCATTERING FOR LASER APPLICATION  
A66-18488
- JACOBS, E. D.  
WAVELENGTH CHANGE OF SPONTANEOUS AND STIMULATED  
EMISSION WITH UNIAXIAL PRESSURE UNDER CW  
OPERATION OF GaAs DIODE LASER AT 4 DEGREES K  
A66-19922
- JACOBS, H.  
RUBY LASER AMPLIFIER AT LIQUID-NITROGEN  
TEMPERATURE TREATED AS THREE-MEDIUM TRANSMISSION  
SYSTEM, NOTING GAIN CHANGE WITH NEGATIVE  
ATTENUATION  
A66-22867
- MULTIPLE REFLECTION THEORY APPLIED TO REGENERATIVE  
LASER AMPLIFIER DESIGN  
ECOM-2531  
N65-19166
- REGENERATIVE RUBY LASER AMPLIFIERS AT LIQUID  
NITROGEN TEMPERATURES  
ECOM-2575  
N65-35642
- JACOBS, S.  
NARROW BAND LASER DOPPLER RADAR NAVIGATION  
INSTRUMENT FOR INSTANTANEOUS GROUND SPEED  
TRG-019-I-1  
N65-27932
- DOPPLER OPTICAL NAVIGATOR TO MEASURE  
INSTANTANEOUS GROUND SPEED WITH 0.1 FT/SEC  
ACCURACY FOR ALTITUDES OF 250 TO 5000 FEET -  
CONTINUOUS WAVE LASER AS TRANSMITTER  
TRG-019-I-2  
N65-28160
- JACOBSON, A. D.  
SINGLE RESONATOR REFLECTION AMPLIFIER ANALYSIS IN  
TERMS OF SCATTERING MATRIX DESCRIPTION OF OPTICAL  
RESONATOR  
A65-25885
- MODE-CONTROLLED GIANT PULSE LASER USED TO PRODUCE  
TWO-BEAM HOLOGRAM IN SHORT EXPOSURE TIME OF 30  
NSEC  
A66-12215
- JAHODA, F. C.  
PLASMA INTERFEROMETRY TECHNIQUE WHERE REFLECTED-  
BACK OUTPUT OF GAS LASER IS MODULATED, USING PHASE  
VARIATIONS  
A65-19754
- JANOWSKI, K.  
RUBY LASER CRYSTAL FLAWS OF CLOSELY PACKED  
SPHEROIDS SUGGESTING PLASTIC FLOW AND QUENCH-IN AS  
CAUSE  
A65-17684
- JARRETT, S.  
NARROW BAND LASER DOPPLER RADAR NAVIGATION  
INSTRUMENT FOR INSTANTANEOUS GROUND SPEED  
TRG-019-I-1  
N65-27932
- DOPPLER OPTICAL NAVIGATOR TO MEASURE  
INSTANTANEOUS GROUND SPEED WITH 0.1 FT/SEC  
ACCURACY FOR ALTITUDES OF 250 TO 5000 FEET -  
CONTINUOUS WAVE LASER AS TRANSMITTER  
TRG-019-I-2  
N65-28160
- JARRETT, S. M.  
CW IR LASER OSCILLATION IN H BR AND HI GAS  
DISCHARGE  
A66-16756
- JASEJA, T. S.  
RUBY LASERS DISCUSSING OUTPUT CHARACTERISTICS,  
BEAM DIVERGENCE, BEAT MODES AND RESPECTIVE  
EXPERIMENTAL TECHNIQUES  
A66-14919
- ISOTOPE SHIFT MEASUREMENT FOR 6328 ANGSTROMS  
HELIUM-NEON LASER TRANSITION  
A66-21070
- JAVAN, A.  
AUTOMATIC FEEDBACK CONTROL FOR LONG-TERM FREQUENCY  
STABILIZATION OF HE- NE LASER AT CENTER  
FREQUENCY OF ATOMIC RESONANCE  
A65-21620
- GASEOUS OPTICAL MASERS CONSIDERING PROBLEM OF  
DOPPLER BROADENED TRANSITION SUBJECTED TO OPTICAL  
FREQUENCY FIELD IN STANDING WAVE FORM  
A65-24005
- PHYSICAL PRINCIPLES OF LASERS AND APPLICATION IN  
STUDYING RADIATION AND MATTER INTERACTION  
A65-26933
- ISOTOPE SHIFT MEASUREMENT FOR 6328 ANGSTROMS  
HELIUM-NEON LASER TRANSITION  
A66-21070
- Q-SWITCHING OF CARBON DIOXIDE AND NITROUS OXIDE  
GAS LASER TRANSITIONS  
A66-23354
- VIBRATIONAL AND ROTATIONAL RELAXATIONS IN CARBON  
DIOXIDE AND NITROUS OXIDE LASER SYSTEMS, USING Q-  
SWITCHING TECHNIQUES  
A66-23355
- JEFFERS, W. Q.  
DIELECTRIC CAVITY MASER COMPOSED OF RUBY ROD  
SEPARATING METAL PLATES, NOTING STRENGTH  
SATURATION BEHAVIOR, POWER OUTPUT, ETC  
A66-21308
- JENNINGS, D. A.  
STIMULATED BRILLOUIN RADIATION IN OFF-AXIS RUBY  
LASER RESONATOR USING CARBON DISULFIDE CELL,  
EXAMINING OUTPUT SPECTRUM  
A65-16811
- STIMULATED RAMAN EFFECT OF BENZENE USING RUBY

- LASER, EXAMINING OUTPUT SPECTRUM, THRESHOLD POWER AND EFFICIENCY AT STOKES LINES  
A65-19598
- JENSEN, R. C.**  
LASER OSCILLATION IN VISIBLE REGION FROM PULSED COLD CATHODE DISCHARGE IN IONIZED S AND P  
A65-33379
- JEPHCOTT, D. F.**  
FREQUENCY RESPONSE AND CROSS COUPLING OF RED AND IR GAS LASER INTERFEROMETER FOR MEASURING PLASMA ELECTRON DENSITY  
A65-15819
- JEUNEHOMME, M.**  
Q-SPOILED RUBY LASER BEAM FOCUSED ON GRAPHITE, OBTAINING SWAN EMISSION OF CARBON MOLECULE  
A65-34207
- JOHNSON, C. C.**  
LINE WIDTHS AND INVERSION RATIOS OF IRON DOPED RUTILE FOR SUITABILITY IN BROADBAND MASERS  
A65-19622
- LINE WIDTH AND INVERSION RATIOS OF IRON-DOPED RUTILE FOR OPTICAL MASER APPLICATIONS  
NASA-TM-X-54754  
N65-29390
- JOHNSON, E. H.**  
COMPARISON OF HYDROGEN MASER AND OF CESIUM BEAM TUBE FREQUENCY STANDARD  
NASA-TN-D-3292  
N66-21698
- JOHNSON, F. M.**  
OUTPUT FREQUENCY QUADRUPLING IN Q-SPOILED NEODYMIUM-IN-GLASS LASER, USING NONLINEAR OPTIC EFFECT  
A65-15858
- JOHNSON, J. H.**  
PHOTOTUBE OBSERVATION OF RUBY LASER OUTPUT AS FUNCTION OF TIME  
N65-15570
- JOHNSON, L. F.**  
LASER CHARACTERISTICS OF AND COHERENT OSCILLATIONS FROM TRIVALENT TM, HO, YB AND ER IONS IN YTTRIUM ALUMINUM GARNET  
A66-10241
- JOHNSON, R.**  
SYSTEM FOR OPTICAL ACQUISITION AND TRACKING, AND LASER BEAM DEFLECTOR DEVICES - ELECTRO-OPTICAL TECHNIQUES FOR CONTROLLING DIRECTION OF LASER BEAM FLOW  
NASA-CR-64222  
N65-30541
- PIEZOELECTRICALLY POWERED LASER BEAM WAVEGUIDE FOR ELECTRO-OPTICAL ACQUISITION AND TRACKING  
NASA-CR-68895  
N66-17291
- JOHNSON, T. S.**  
REFLECTED RADIATION OF Q-SPOILED RUBY LASER FROM EXPLORER XXII  
A65-21306
- JOHNSON, V. R.**  
PHONON-PHOTON INTERACTIONS IN OPTICAL SOURCES - THEORETICAL DESCRIPTION OF BRAGG AND RAMAN-NATH SCATTERING CAUSED BY PROPAGATION OF PLANE ACOUSTIC WAVE THROUGH LASER BEAM PATH  
AFOSR-65-2647  
N66-22449
- JOHNSON, W. B.**  
GASEOUS AND SOLID LASER LINES SURVEY FOR LASER SPECTROSCOPY AND PLASMA DIAGNOSTICS  
NASA-CR-57334  
N65-19752
- LASERS AND LASER SPECTROSCOPY - LIGHT MODULATION AND DEMODULATION METHODS, LASER TRANSITIONS, RAMAN EFFECT INITIATION, AND NONLINEAR OPTICAL PHENOMENA  
TR-A-34  
N65-19791
- JONES, D. G. C.**  
DESIGN AND OPERATION OF HELIUM-NEON LASER NOTING RADIATION, FREQUENCY STRUCTURE, POWER DENSITY, EXTERNAL MAGNETIC FIELD EFFECT, APPLICATION, ETC  
A66-22980
- JONES, D. M. A.**  
EVALUATION OF MASER-EQUIPPED WEATHER RADAR SET AND AREA PRECIPITATION MEASUREMENT INDICATOR -
- METEOROLOGICAL SENSING DEVICE - ELECTRONICS GPR-1  
N66-14191
- MASER EQUIPPED WEATHER RADAR AND PRECIPITATION MEASUREMENT INDICATOR  
GPR-2  
N66-19957
- JORDAN, P. R.**  
RADIOMETRIC PERFORMANCE OF SOLID STATE SUPERHETERODYNE RECEIVER COMPARABLE TO THAT OBTAINED WITH MASERS AND PARAMETRIC AMPLIFIERS  
A66-12437
- JUNKER, H.**  
REABSORPTION AS DOMINANT LOSS MECHANISM FOR BOTH INCOHERENT AND COHERENT RADIATION IN GALLIUM ARSENIDE LUMINESCENT DIODE  
A65-30347
- TIME RESOLVED SPECTRA FOR PULSE OPERATED GALLIUM ARSENIDE LASER DIODES  
A65-33372
- HOLE AND ELECTRON SHEARING AND P-TYPE ABSORPTION INFLUENCE ON THRESHOLD CURRENT  
A66-23478
- K**
- KACZMAREK, F.**  
POLISH-MADE HE- NE RED GAS LASERS, DESCRIBING POWER OUTPUTS, GAS PRESSURE, HE/ NE RATIO, MIRROR TRANSMISSION COEFFICIENT AND INTERFEROMETRIC APPLICATION  
A66-23946
- KAFALAS, P.**  
RUBY LASER Q-SWITCHING USING PASSIVE SOLID STATE OR LIQUID ORGANIC BLUE DYE  
TG-B-64-15  
N65-22933
- KAINER, S.**  
LASER BEAM BEYOND-HORIZON COMMUNICATION BY MEANS OF CLOUD AND HAZE SCATTERING  
A65-19596
- LASER COMMUNICATIONS LINK SECURITY AGAINST INTERCEPTION, EXAMINING FREQUENCY BANDWIDTH FOR MINIMUM SNR  
A66-16650
- KAINZ, J. J.**  
PINCH METHODS OF GAS DISCHARGE AS LIGHT SOURCE FOR OPTICAL PUMPING OF VARIOUS LASER MATERIALS  
N65-22742
- KAKINUMA, T.**  
OBSERVATIONS OF RADIO SOURCES AT 9.4 GC WITH 2.2 FOOT FAN BEAM OF 16-ELEMENT INTERFEROMETER AND MASER AMPLIFIER  
A65-28335
- KAKIZAKI, K.**  
GAIN SATURATION, LIGHT POWER LEVEL, DISCHARGE CURRENT AND METHOD FOR SPECIFYING OUTPUT POWER CHARACTERISTICS OF LASER TUBE  
A65-15326
- KALIANOVA, M. P.**  
TREATMENT OF STEEL WITH LASER BEAM, OBTAINING PRECISION HOLES WITHOUT AFFECTING MICROHARDNESS OF METAL  
A66-24898
- KALIBJIAN, R.**  
LASER BEAM DEFLECTION MODULATION OBTAINED BY PASSING CURRENT THROUGH CADMIUM SULFIDE PRISM WITH OHMIC CONTACTS, USED FOR THERMOCOUPLE MEASUREMENTS  
A65-25890
- KALININ, I. A.**  
PULSE ENERGY AND POWER OF LASERS UNDER CONTINUOUS OPERATING CONDITIONS MEASURED, USING CALORIMETERS, PHOTOELECTRIC EFFECT OF RADIATION, ETC  
A66-13205
- KALININ, V. P.**  
THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE LOSSES IN FABRY-PEROT RESONATORS DUE TO MIRROR MISALIGNMENT  
A65-36053
- THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE LOSSES IN FABRY-PEROT RESONATORS DUE TO MIRROR MISALIGNMENT  
A66-15856
- KALITEEVSKII, N. I.**  
INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY AFTER LEAVING LASER AND AFTER FOCUSING WITHIN

- LENS, NOTING OPTIMUM FOCUSING CONDITIONS  
A65-36050
- INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY  
AFTER LEAVING LASER AND AFTER FOCUSING WITHIN  
LENS, NOTING OPTIMUM FOCUSING CONDITIONS  
A66-15853
- KAMAL, A. K.  
DIRECT CURRENT POLARIZATION IN NONLINEAR  
DIELECTRIC MEDIUM AT OPTICAL FREQUENCY  
TR-EE-64-5  
N65-22518
- TWO TYPES OF NONLINEAR INTERACTION OF INTENSE  
LASER BEAM WITH DIELECTRIC MEDIUM - NONLINEAR  
DC POLARIZATION AND SUBHARMONICS GENERATION AT  
OPTICAL FREQUENCIES  
AD-618473  
N65-33899
- KAMINOW, I. P.  
BEHAVIOR OF COUPLING-TYPE INTERNAL LASER  
MODULATORS WITH BANDWIDTH COMPARABLE TO MODE  
SPACING  
A65-16404
- OPTICAL PHASE MODULATOR USING FERRCELECTRIC  
BARIUM TITANATE CRYSTAL PLATE  
A66-10240
- KAMINSKII, A. A.  
CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT  
ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH  
NEODYMIUM IONS  
A65-31703
- DYSPROSIUM DOPED CALCIUM FLUORIDE DOPED LASER,  
USING SOLAR RADIATION FOR EXCITATION AND OPERATING  
AT 77 DEGREES K  
A65-36361
- CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT  
ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH  
NEODYMIUM IONS  
A66-19956
- KAMIRYO, K.  
OPTICAL DESIGN OF ELLIPTICAL CAVITIES AND  
COMPARISON OF ENERGY TRANSFERS FROM LIGHT SOURCE  
TO RUBY LASER WITH CYLINDRICAL CAVITIES  
A66-16647
- KAMIYAMA, M.  
STIMULATED EMISSION IN SILICATE GLASS LASER  
CONTAINING NEODYMIUM  
A65-24189
- PRESSURE DEPENDENCE OF OUTPUT OF HELIUM-NEON  
GASEOUS LASER IN HIGH PRESSURE RANGE  
A66-11375
- KAN, F.-H.  
TRANSMISSION CHARACTERISTICS OF NEODYMIUM LASER  
N66-16812
- KANNELAUD, J.  
BEAT FREQUENCIES AND COHERENCE PROPERTIES IN  
CIRCULARLY POLARIZED ATOMIC TRANSITIONS OF GASEOUS  
LASERS WITH AXIAL MAGNETIC FIELDS  
A66-18429
- BEAT FREQUENCY AND ROTATION OF POLARIZATION PLANE  
IN HE-NE LASER WITH AXIAL MAGNETIC FIELD  
A66-18430
- KAND, T.  
OPTICAL DESIGN OF ELLIPTICAL CAVITIES AND  
COMPARISON OF ENERGY TRANSFERS FROM LIGHT SOURCE  
TO RUBY LASER WITH CYLINDRICAL CAVITIES  
A66-16647
- KAPANY, N. S.  
WAVEGUIDE COUPLING BETWEEN ADJACENT PARALLEL  
FIBERS AS MEANS OF TRANSFERRING RADIATION FROM  
ONE ELEMENT TO ANOTHER  
A66-14827
- KAPUSCIENSKI, S.  
SYSTEM FOR OPTICAL ACQUISITION AND TRACKING, AND  
LASER BEAM DEFLECTOR DEVICES - ELECTRO-OPTICAL  
TECHNIQUES FOR CONTROLLING DIRECTION OF LASER  
BEAM FLOW  
NASA-CR-64222  
N65-30541
- PIEZOELECTRICALLY POWERED LASER BEAM WAVEGUIDE FOR  
ELECTRO-OPTICAL ACQUISITION AND TRACKING  
NASA-CR-68895  
N66-17291
- KARNEY, J. L.  
LASER RADAR AS INSTRUMENT TO OBTAIN OPERATIONAL  
METEOROLOGICAL INFORMATION  
A66-21067
- KARRAS, H.  
SPECTROSCOPIC DATA ON ABSORPTION, SPONTANEOUS  
FLUORESCENCE AND STIMULATED EMISSION IN ACTINIDES,  
TRANSITION METAL AND SEMICONDUCTOR LASER MATERIAL  
A65-21168
- KARTASCHOFF, P.  
FREQUENCY STANDARDS OF HYDROGEN MASER AND SWISS  
CESIUM ATOMIC BEAM TUBE COMPARED  
A65-16681
- KASSEL, S.  
GAS IONIZATION IN FOCUSED RUBY LASER BEAM  
N65-21219
- KASTLER, A.  
HYPERSONIC WAVES PRODUCED BY BRILLOUIN EFFECT,  
USING METHOD OF TWO INTENSE LIGHT BEAMS  
A65-14874
- HYPERSONIC WAVE GENERATION BY SUPERPOSITION OF  
TWO COHERENT LIGHT BEAMS IN SOLID OR LIQUID  
DIELECTRIC  
A65-15880
- KATS, L. I.  
OUTPUT POWER OF CW LASER MEASURED BY WIRE  
BOLOMETER IN FORM OF PLANE SINGLE-LAYER SPIRAL AS  
SENSITIVE ELEMENT  
A66-20364
- KATULIN, V. A.  
EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER  
WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF  
FORBIDDEN BAND IN GALLIUM ARSENIDE  
A65-31307
- EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER  
WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF  
FORBIDDEN BAND IN GALLIUM ARSENIDE  
A65-33354
- INDUCED RADIATION IN GA AS SEMICONDUCTOR CRYSTAL  
EXCITED BY RUBY LASER WITH Q-MODULATION  
A65-35842
- INDUCED RADIATION AND LASER ACTION OF GALLIUM  
ARSENIDE SINGLE CRYSTAL EXCITED BY LIGHT FROM  
Q-MODULATED RUBY LASER  
A65-36362
- GENERATION IN CADMIUM SULFIDE DURING TWO-PHOTON  
OPTICAL EXCITATION BY RUBY LASER WITH MODULATED  
Q-FACTOR  
A66-19620
- KATZENSTEIN, J.  
MULTICHANNEL PHOTOELECTRIC SPECTRUM ANALYZER WITH  
KERR CELL GATING RECORDS SPECTRUM OF LASER LIGHT  
SCATTERED FROM SINGLE GIANT PULSE IN PLASMA  
A65-28203
- KATZMAN, M.  
BEAM DIVERGENCE AND FAR-FIELD PATTERNS OF RUB RODS  
OF VARYING OPTICAL QUALITY  
A65-35315
- LASER EXCITATION IN QUARTZ OF ELASTIC MODES OF  
THICK PLATE, SUGGESTING ENERGY COUPLING MECHANISMS  
A66-12423
- KATZMANN, M.  
OPTICAL AND LASER THRESHOLD MEASUREMENTS ON 39  
FLAME-FUSION RUBIES TO OBTAIN HIGHEST OPTICAL  
QUALITY LASER RODS  
A65-16402
- KAVAGE, M. T.  
PARAMETRIC EXCITATION OF ACOUSTIC WAVES IN  
SIMULATED BRILLOUIN SCATTERING  
REPT.-1935-5  
N65-29906
- KAWAGUTI, M.  
OSCILLATION CHARACTERISTICS OF RUBY LASER WITH  
EXTERNAL MIRRORS OF LARGE SPACING  
A65-33517
- KAWAJI, A.  
SINGLE FILAMENT JUNCTION LASER EMITTING COHERENT  
LIGHT OF SIMPLER MODES, SHOWING THAT LASER HAS TWO  
PORTIONS, EACH WITH SELECTIVE DIFFUSED REGION

- A66-21357
- KAY, I.**  
COHERENT TRANSFER CHARACTERISTICS OF OPTICAL SYSTEM, HOLOGRAMS AND COMPLEX SPATIAL FILTERS, AND LASER APPLICATIONS  
D-5210-72-T80-110 N65-21691
- KAY, R. B.**  
RATE EQUATION SOLUTIONS FOR Q-SPOILED AND PULSED TRANSMISSION MODE / PTM/ OPERATION OF THREE-LEVEL LASER A65-22933
- KAZANTSEV, A. P.**  
INDUCED EMISSION MODES OF TRAVELING WAVE LASER A66-10778  
INDUCED EMISSION MODES OF TRAVELING WAVE LASER A66-22290
- KAZARINOV, R. F.**  
QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION A65-28487  
QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION A66-12086
- KECK, J. C.**  
GROWTH OF WAVES IN PULSED LASER AMPLIFIER CALCULATED USING QUASI ONE-DIMENSIONAL MODEL - AMPLIFICATION OF EXTERNALLY IMPRESSED AND SPONTANEOUSLY EMITTED WAVES  
AVCO-EVERETT RES. REPT.-233 N66-10972
- KEHL, D.**  
PARAMETRIC CONVERSION OF OPTICAL FREQUENCIES IN CRYSTAL ILLUMINATED BY LASERS A65-28626  
Q-SWITCHED OPTICAL MASER SYNCHRONIZATION, DISCUSSING EXPERIMENTAL DESIGN, SETUP AND PERFORMANCE A66-17297
- KELLER, C. H.**  
OPTIMIZING FLASH LAMPS FOR PUMPING LASER RODS BY MEANS OF DOPING AD-613346 N65-25890
- KELLER, D. V.**  
IMMERSION LIQUIDS FOR HIGH ENERGY RUBY LASERS WITH MATCHING REFRACTIVE INDEXES TRANSPARENT AT RUBY PUMPING AND LASING WAVELENGTHS A65-22625
- KELLINGTON, C. H.**  
OPTICAL AND LASER THRESHOLD MEASUREMENTS ON 39 FLAME-FUSION RUBIES TO OBTAIN HIGHEST OPTICAL QUALITY LASER RODS A65-16402  
BEAM DIVERGENCE AND FAR-FIELD PATTERNS OF RUB RODS OF VARYING OPTICAL QUALITY A65-35315
- KENT, G. S.**  
LOWER ATMOSPHERIC DENSITY MEASUREMENTS THROUGH LIGHT SCATTERING FROM Q-SPOILED RUBY LASER BEAM, USING OPTICAL RADAR DETECTOR A66-20398
- KERBYSON, G. H.**  
CHARACTERISTICS, AND LIMITATIONS OF LASERS FOR APPLICATION IN MILITARY AND SPACE SYSTEMS - CRYSTAL, GLASS, GAS, LIQUID, SEMICONDUCTOR, AND QUASI-LASERS  
LMSC-704217 N65-26625
- KERR, J. R.**  
SYSTEM TRANSLATING FREQUENCY OF GAS LASER OVER RANGE OF SEVERAL GIGACYCLES, ELIMINATING NEED FOR ELECTRO-OPTIC CRYSTALS WITH CUBIC SYMMETRY A65-25872  
COHERENT INTERFERENCE REJECTION, DISCUSSING NOISE AND MODULATOR-LEAKAGE PICKUP REJECTION IN LASER COMMUNICATIONS EXPERIMENTS A66-17217
- KEYES, R. W.**  
THERMAL LIMITATIONS ON CAPABILITIES OF GALLIUM ARSENIDE P-N JUNCTION LASERS A66-10895
- KHAN, S. H.**  
TIME RESOLUTION OF ELECTRON AND ION EMISSION PRODUCED BY Q-SWITCHED RUBY LASER PULSE FOCUSED ON METAL SURFACE A66-18358
- KHATKEVICH, A. G.**  
LIGHT WAVE FREQUENCY CONVERSION BY LASER CRYSTAL, EXAMINING RESULTANT HARMONICS A65-15508
- KHECHT, W. L.**  
PERFORMANCE CHARACTERISTICS OF GALLIUM ARSENIDE AND MIXED-CRYSTAL INJECTION LASERS SURPASS ALL OTHER LASERS IN EFFICIENCY AND CW POWER OUTPUT A65-24130
- KHEIFETS, M. I.**  
RADIATIVE REACTION EFFECTS ON GIANT PULSE LASER STABILITY IN ANISOTROPIC MEDIUM A65-20913  
DEGREE OF EXCITATION OF METASTABLE STATE DETERMINED, USING LUMINESCENCE SATURATION PHENOMENON, CALCULATING POPULATION OF WORKING LEVEL OF LASER SUBSTANCE A66-22027
- KHOKHLOV, R. V.**  
NONLINEAR PROPAGATION OF PULSE SIGNAL IN LASER TYPE TRAVELING WAVE AMPLIFIER A66-11841  
OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-15352  
OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-20893  
GAS DISCHARGE BY LASER PULSE, TAKING INTO ACCOUNT PHOTOIONIZATION DUE TO ELECTRON IMPACT A66-24887  
CONSISTENT THEORY OF NONLINEAR OPTICAL EFFECTS IN BOUNDED LIGHT BEAMS BY EXTENDING PARABOLIC EQUATIONS TO NONLINEAR PROBLEMS A66-24888  
NONLINEAR OPTICS - LASERS, RAMAN SCATTERING, AND OPTICAL RESONATORS  
JPRS-29459 N65-21141
- KIANG, Y. C.**  
LASER MODULATION AT ATOMIC LEVEL - POPULATION INVERSION AND ESTIMATE OF ZEEMAN SPLITTING  
NASA-CR-60572 N65-16320  
RUBY LASER MODULATION AT ATOMIC LEVEL - FREQUENCY SHIFT MEASUREMENT OF LASER EMISSION UNDER INHOMOGENEOUS MAGNETIC FIELD BY SPECTROSCOPY  
NASA-CR-57464 N65-19863  
LASER MODULATION AT ATOMIC LEVEL - YTTRIUM-ALUMINUM GARNET EMISSION AND LASER EMISSION SHIFT WITH HOMOGENEOUS PULSED MAGNETIC FIELD  
NASA-CR-57823 N65-21308  
MEASUREMENT OF TEMPERATURE DEPENDENCE OF ENERGY LEVELS INVOLVED IN LASER EMISSION  
NASA-CR-64436 N65-32191
- KIDD, D. E.**  
ELECTRON DENSITY MEASUREMENTS IN PLASMA PRODUCED BY COMBINATION OF RF AND VERY FAST THETA-PINCH DISCHARGES, USING GAS LASER INTERFEROMETER A65-29848  
TIME-DEPENDENT ELECTRON DENSITY VARIATION STUDIED IN FAST THETA-PINCH DISCHARGE, USING HE-NE GAS LASER INTERFEROMETER A65-29849
- KIDDER, R. E.**  
STABILITY OF CORRECTED COUPLED-MODE LASER EQUATION DERIVED FROM MODEL FOR RUBY LASER SPIKING RESULTING FROM MODE INTERFERENCE A65-29805  
TIME DEPENDENCY OF COUPLED MODE LASER OSCILLATION  
UCRL-7497 N66-20355



- KIEFER, J. E.  
LASER COMMUNICATION SYSTEMS STUDY  
FR-64-19-301 N65-17940
- COHERENT LIGHT COMMUNICATION SYSTEM FOR ATMOSPHERE  
CONDITION EFFECTS ON FREQUENCY MODULATED LASER  
BEAM  
FR-66-14-37 N66-21774
- KIKUCHI, T. T.  
LASER OSCILLATION IN DECAY OF EXCITED MOLECULES  
FROM CHEMICAL REACTION, NOTING CHANGE IN THREE  
ELECTRONIC LEVELS IN MOLECULAR SYSTEM  
A65-20069
- LASER TRANSITION IN VIBRATIONAL STATE OF GROUND  
ELECTRONIC STATE OF CN FROM ROTATIONAL LEVEL 8 TO  
7 WITH POPULATION INVERSION AS RESULT  
A66-11451
- KILCOYNE, M. R.  
COHERENCE THEORY FOR COLLIMATION AND FOCUSING OF  
TIME-AVERAGED INTENSITY OF PULSED MULTIMODE LASER  
RADIATION  
A66-12205
- FOCUSING AND COLLIMATION PROPERTIES OF PULSED  
MULTIMODING RUBY LASER  
REPT.-1579-19 N65-21554
- KIM, P. H.  
GIANT RUBY LASER PULSE PRODUCTION FROM RAPID  
SATURATION OF DYE ABSORBER SOLUTION IN OPTICAL  
CAVITY BY SINGLET-SINGLET TRANSITIONS  
A65-33521
- KINDLMANN, P. J.  
MEASUREMENT OF GAS LASER RADIATIVE DECAY RATES AND  
TOTAL INELASTIC DESTRUCTIVE CROSS SECTION OF SHORT  
LIVED EXCITED STATES IN 4-NSEC TO 1000-NSEC RANGE  
A65-20061
- KING, M.  
LASER BEAM BEYOND-HORIZON COMMUNICATION BY MEANS  
OF CLOUD AND HAZE SCATTERING  
A65-19596
- KINGSLAND, D. O.  
THOMSON SCATTERED LASER RADIATION USED TO  
DETERMINE ELECTRON DENSITY IN HELIUM PLASMA,  
EXAMINING THYRATRON TUBE AND VOLTAGE PROBE USE  
A65-19618
- KINGSLEY, J. D.  
LASER EMISSION FROM N TYPE GALLIUM ARSENIDE  
CRYSTAL BY FAST ELECTRON EXCITATION, NOTING DOPING  
AND EMISSION ENERGY  
A65-19546
- KINGSTON, R. H.  
STIMULATED EMISSION EVIDENCE FROM NITROGEN COOLED  
SPIKING RUBY-LASER-IRRADIATED DEGENERATED P-TYPE  
GaAs CRYSTALS  
A65-15323
- PULSED LASER DOSIMETER THAT MEASURES DANGER LEVEL  
OF RADIATION OF DIRECT OR REFLECTED BEAMS AS  
SAFEGUARD TO EYE DAMAGE  
A65-21951
- KINNEY, M.  
BIBLIOGRAPHY ON BIOLOGICAL EFFECTS AND HAZARDS OF  
LASER RADIATION  
TS-1245/3111 N65-33997
- KIRCHNER, L. P.  
MACH-ZEHNDER LASER INTERFEROMETER AS DIAGNOSTIC  
TOOL IN SHOCK TUBE EXPERIMENTS  
A66-23352
- KIRKBY, C. J.  
MAGNITUDE OF ANISOTROPIC LINE BROADENING IN RUBY  
A66-13278
- KISELEV, A. A.  
CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW  
A66-11190
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW  
A66-24011
- KLEBBA, A. A.  
MINORITY CARRIER LIFETIME IN SILICON MEASURED BY  
CONTACTLESS METHOD, USING LASER INDUCED MODULATION  
OF IR TRANSMISSION IN SILICON / LIMIRIS/ EFFECT  
A66-14563
- KLEIN, C. A.  
LASER-ACTION THRESHOLD IN ELECTRON-BEAM EXCITED  
GALLIUM ARSENIDE AND EFFECT OF TEMPERATURE AND  
DOPING  
A66-10971
- KLEIN, D. J.  
RUBY LASER PULSE TECHNIQUE APPLIED TO THERMAL  
DIFFUSIVITY MEASUREMENTS FOR TANTALUM AND  
GRAPHITE  
CONF-651020-1 N66-18228
- KLEIN, E.  
GALLIUM ARSENIDE LASER DIODES BEHAVIOR AT HIGH  
PULSE RADIATION LOADS  
A65-29356
- KLEINERMAN, M.  
ENERGY TRANSFER IN RARE EARTH CHELATES -  
IMPLICATIONS FOR ORGANIC LASER DESIGN  
N65-15505
- KLEINHANS, W.  
EFFICIENT DIFFRACTION OF INCIDENT LASER BEAM AT  
BRAGG ANGLE INCIDENCE INTO FIRST-ORDER MODE,  
USING TRAVELING ULTRASONIC WAVES IN WATER  
A65-33057
- KLEMAN, B.  
LASER IRRADIANCE LEVELS FOR RETINAL LESIONS  
A66-80011
- KLEMENTEV, V. M.  
LASER WITH HOLLOW CATHODE DISCHARGE ON NEON-  
HYDROGEN MIXTURE AND CAVITY FORMED BY CYLINDRICAL  
MIRRORS  
A65-25590
- OPTICAL RESONATOR USING CYLINDRICAL MIRROR WITH  
VARIABLE RADIUS OF CURVATURE  
A66-13890
- KLEMENTEV, W. M.  
LASER WITH HOLLOW CATHODE DISCHARGE ON NEON-  
HYDROGEN MIXTURE AND CAVITY FORMED BY CYLINDRICAL  
MIRRORS  
A66-11421
- KLEPPNER, D.  
HYDROGEN MASER CONSTRUCTION AND OPERATION DESIGN  
PRINCIPLES EMPHASIZING MICROWAVE CAVITY, LOW  
MAGNETIC FIELD, HYDROGEN STORAGE AND MASER TUNING  
TECHNIQUES  
A65-24309
- DIRECT FREQUENCY COMPARISON OF ATOMIC HYDROGEN  
MASERS IN DIFFERENT PLACES AND CONDITIONS BY  
SIMULTANEOUS MONITORING OF LORAN C SIGNALS  
A66-24145
- KLINE, C. R.  
LASER APPLICATION IN MEDICINE, MANUFACTURING,  
SPECTROSCOPY, OPTICS AND COMMUNICATIONS  
A65-31882
- KLOHN, K. L.  
GALLIUM ARSENIDE LASER DIODES WITH HIGH OUTPUT  
COHERENT BEAM FOR COMMUNICATIONS SYSTEMS  
ECOM-2629 N66-21293
- KLOTZBAUGH, G. A.  
USE OF LASER BEAM IN SPECTROGRAPHIC ANALYSIS -  
NORMAL LASER AND GIANT SPIKE LASER  
AFCL-65-586 N66-12799
- KLUVER, J. W.  
CRYSTALLINE CALCITE USED AS DICHROIC POLARIZER IN  
IR REGIONS, LASER RADIATION, ZEEMAN EFFECT AND  
NOISE PROPERTIES MEASUREMENTS, ETC  
A65-33419
- KMENT, V.  
RUBY-LASER ROD HOMOGENEITY DETERMINATION BY  
INTERFEROMETERS  
A65-19569
- KNECHT, W. L.  
ENERGY MEASUREMENT OF RUBY LASER INDUCED ELECTRON  
EMISSION FROM TUNGSTEN  
A65-20241
- LIFE PERFORMANCE CHARACTERISTICS OF UNCOATED RUBY  
LASER Q-SWITCHED BY ROTATING PRISM FORMING END

- REFLECTOR OF LASER RESONATOR A66-16675
- KNESTRICK, G. L.**  
COMPARISON OF UNDERWATER ATTENUATION OF RUBY  
LASER LIGHT WITH NONLASER LIGHT  
NRL-6181 N65-28158
- KNIAZEV, I. N.**  
LASER PULSE GENERATION WITH PLASMA RESULTING FROM  
DISCHARGE IN HYDROGEN AS MEDIUM A65-22728
- KOBAYASHI, S.**  
PRESSURE DEPENDENCE OF OUTPUT OF HELIUM-NEON  
GASEOUS LASER IN HIGH PRESSURE RANGE A66-11375
- KOCHER, R.**  
MICROWAVE ELECTRON CYCLOTRON RESONANCE PUMPING OF  
NEON-HELIUM LASER TO RAISE PLASMA ELECTRON  
TEMPERATURE FOR INCREASE OF OUTPUT A65-15320
- KOESTER, C. J.**  
DETERMINATION OF ATTENUATING FILTERS REQUIRED FOR  
EYE PROTECTION AGAINST LASER RADIATION A65-22614
- GLASS FIBER LASERS FOR OPTICAL DATA PROCESSING  
ADRC-4502-16-564-42 N66-11060
- KOETITZ, G.**  
SPECTROSCOPIC DATA ON ABSORPTION, SPONTANEOUS  
FLUORESCENCE AND STIMULATED EMISSION IN ACTINIDES,  
TRANSITION METAL AND SEMICONDUCTOR LASER MATERIAL A65-21168
- KOKORA, A. N.**  
TREATMENT OF STEEL WITH LASER BEAM, OBTAINING  
PRECISION HOLES WITHOUT AFFECTING MICROHARDNESS OF  
METAL A66-24898
- KOLLBERG, E.**  
L-BAND TRAVELING-WAVE MASER FOR RADIO ASTRONOMY  
RESEARCH AT 21 CM USES CHROMIUM-DOPED RUTILE  
A66-16640
- KOLOMIKOV, I. D.**  
GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM  
INCIDENT ON PLANE PARALLEL GLASS PLATE OF  
RESONATOR A65-18555
- LASER WITH HOLLOW CATHODE DISCHARGE ON NEON-  
HYDROGEN MIXTURE AND CAVITY FORMED BY CYLINDRICAL  
MIRRORS A65-25590
- GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM  
INCIDENT ON PLANE PARALLEL GLASS PLATE OF  
RESONATOR A65-27148
- LASER WITH HOLLOW CATHODE DISCHARGE ON NEON-  
HYDROGEN MIXTURE AND CAVITY FORMED BY CYLINDRICAL  
MIRRORS A66-11421
- OPTICAL RESONATOR USING CYLINDRICAL MIRROR WITH  
VARIABLE RADIUS OF CURVATURE A66-13890
- KOMAI, L. G.**  
NEODYMIUM GLASS LASERS AND GENERATION OF HOLE  
BURNING SPECTRAL FLUXES  
AD-464366 N65-31836
- KOMPNER, R.**  
ECONOMICAL FEASIBILITY REQUIREMENTS FOR OPTICAL  
MASER COMMUNICATIONS SYSTEMS A66-11301
- KONIKHOV, V. K.**  
EMISSION SPECTRUM OF RUBY LASER WITH EXTERNAL  
SPHERICAL MIRRORS IN NONDAMPING INTENSITY  
FLUCTUATIONS AND QUASI-STEADY GENERATION A65-21041
- CD S SINGLE CRYSTAL OPTICAL GENERATOR DURING  
EXCITATION BY RUBY LASER, DISCUSSING TWO-PHOTON  
ABSORPTION COEFFICIENT AT 300 DEGREES K FOR  
RADIATION FLUX DENSITIES A66-13874
- LASER REGIME WITH GIANT PULSES GENERATED IN  
DYSPROSIUM DOPED CADMIUM FLUORIDE UNDER CONTINUOUS
- PUMPING BY XENON LAMPS, OBTAINING Q FACTOR  
MODULATION BY ROTATING PRISM A66-19376
- KONNERTH, K.**  
JUNCTION REGION HEATING OF FABRY-PEROT GA AS  
INJECTION LASER TREATED BY THREE TECHNIQUES A65-26819
- SWITCHING CHARACTERISTICS OF NEGATIVE RESISTANCE  
DIODE DETERMINATION - INJECTION LASER  
REPT.-7 N65-27203
- KONONCHUK, G. L.**  
CHROMIUM INDUCED LIGHT DISPERSION IN R LINES OF  
RUBY, NOTING REFRACTION SHIFT IN LASER SPECTRUM  
A65-20260
- KONSTANTINOV, O. V.**  
QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION  
AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION  
A65-28487
- QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION  
AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION  
A66-12086
- KOOZEKANAI, S. H.**  
TRANSITION PROBABILITIES FOR AR II LASER LINES  
COMPARED WITH PREVIOUS THEORETICAL AND  
EXPERIMENTAL DATA A65-29799
- KOOZEKANANI, S.**  
EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASERS S-705 N65-15980
- GAS LASERS - LEVEL POPULATION DEPENDENCES, LASER  
POWER OUTPUT, METASTABLE DENSITY MEASUREMENTS,  
AND PARAMETER CHANGE EFFECT ON MATHEMATICAL  
MODEL OF LASER SYSTEM N65-20002
- EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASER, XENON LIFETIMES, AND THEORY OF  
DIFFUSION CONTROLLED GLOW DISCHARGE  
S-669 N65-28779
- KOOZEKANANI, S. H.**  
I R LASER ACTION IN ARGON II BETWEEN 1 AND 2  
MICRONS AND IN 6000 TO 7000 ANGSTROM RANGE  
A65-17207
- KOPYLOVSKII, B. D.**  
SEMICONDUCTOR-BASED PULSE GENERATOR FOR LASER  
EXCITATION A66-11042
- SEMICONDUCTOR-BASED PULSE GENERATOR FOR LASER  
EXCITATION A66-23289
- KORNEEVA, O. G.**  
MEASUREMENT OF RADIATION PATTERN OF RUBY LASER  
EMISSION FOR VARIOUS RESONATORS AND OPERATING  
REGIMES, NOTING LASER EFFECT ON ANGULAR HALF-WIDTH  
VALUES A66-22028
- KORNIENKO, L. S.**  
CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT  
ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH  
NEODYMIUM IONS A65-31703
- DYSPROSIUM DOPED CALCIUM FLUORIDE DOPED LASER,  
USING SOLAR RADIATION FOR EXCITATION AND OPERATING  
AT 77 DEGREES K A65-36361
- CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT  
ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH  
NEODYMIUM IONS A66-19956
- KOROBKIN, V. V.**  
HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE  
EXCITATION AND GENERATION KINETICS IN RUBY LASER  
WITH CONCENTRIC CAVITY A65-18460
- HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE  
EXCITATION AND GENERATION KINETICS IN RUBY LASER  
WITH CONCENTRIC CAVITY A65-28089
- H F MODULATION OF RADIATION SPIKES DUE TO BEATS  
BETWEEN OSCILLATION MODES IN OPTICAL RUBY LASER

KREMENEK, C. R.

- I-173**

- MILLIMETER AND SUBMILLIMETER MASER DEVICES -  
MEASURING TECHNIQUES FOR ZERO FIELD MASER  
REPT.-490G N65-33895
- MILLIMETER AND SUBMILLIMETER MASER DEVICES - IRON-  
DOPED MASER AMPLIFIER, PUSH-PULL RUTILE MASER,  
AND X-BAND ZERO FIELD MASERS  
REPT.-490H N66-16210
- KREUZER, J.  
LASER LIGHT REDISTRIBUTION IN ILLUMINATING OPTICAL  
SIGNAL PROCESSING SYSTEMS NOTING APODIZATION,  
SPATIAL MODES AND ASPHERIC ELEMENTS  
A66-14830
- KRINDACH, N. I.  
CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER  
A66-10704
- CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER  
A66-23309
- KRIUKOV, P. G.  
TIME PARAMETERS OF POWERFUL LASER MEASURED WITH  
GA AS PHOTODIODE, NOTING TIME CONSTANT AND TIME  
RESOLUTION OF PHOTODIODE  
A65-34552
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A65-35877
- PROPAGATION RATE OF HIGH POWER LASER LIGHT PULSE  
IN INVERSELY POPULATED MEDIUM  
A66-15333
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A66-18972
- NONLINEAR AMPLIFICATION OF LIGHT PULSE PASSING  
THROUGH LASER OPERATING AT SATURATION REGIME  
A66-21963
- KROEGER, R. D.  
MOTION SENSING BY OPTICAL HETERODYNE DOPPLER  
DETECTION FROM DIFFUSE SURFACES, EXAMINING SPATIAL  
COHERENCY OF SIGNAL  
A65-19628
- KROENING, J. L.  
RUBY LASER IN OPTICAL RADAR PROBE SYSTEM FOR  
BALLOON SOUNDING OF STRATOSPHERIC AEROSOL  
N65-30205
- KROKHIN, O. N.  
LASER EMISSION USED FOR HEATING PLASMA WITH  
INITIAL DENSITY NEAR ZERO  
A65-15535
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A65-35877
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A66-18972
- EXCITATION OF AXIAL OSCILLATION MODES IN  
SEMICONDUCTOR LASERS ANALYZED, BASED ON RATE  
EQUATIONS FOR CHEMICAL POTENTIALS OF CARRIERS AND  
NUMBER OF PHOTONS  
A66-24455
- KROPOTOVA, O. D.  
CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW  
A66-11190
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW  
A66-24011
- KRUEGER, H.  
COMPTON SCATTERING OF LASER PHOTONS, NOTING  
TRANSFORMATION INTO GAMMA RADIATION PHOTONS UPON  
COLLISION WITH HIGH ENERGY ELECTRONS  
A66-17816
- KRUPKE, W. F.  
HIGH QUANTUM EFFICIENCY IN NARROW BAND TRIVALENT  
RARE EARTH DOPED QUANTUM COUNTER ACHIEVED BY LASER  
PUMPING  
A65-27604
- KRUPNOV, A. F.  
SPECTRAL LINE SHAPE FOR FABRY-PEROT MASER USING  
VARIOUS OSCILLATION MODES  
A65-14113
- BEAM MASER EXCITATION PARAMETER CALCULATIONS  
INCLUDING COLLISION IN BEAM EFFECTS AND COMPARISON  
WITH MOLECULAR FORMALDEHYDE  
A65-24825
- SPECTRAL LINE SHAPE FOR FABRY-PEROT MASER USING  
VARIOUS OSCILLATION MODES  
A65-24933
- PARAMETER OF EXCITATION OF MOLECULAR BEAM TYPE  
MASER RESONATOR  
N65-27253
- KSANDER, Y.  
RAMAN SCATTERING LASERS  
N65-32677
- LASER-INDUCED NONLINEAR EFFECTS, RAMAN  
SCATTERING, AND GAS BREAKDOWN - SOVIET  
LITERATURE REVIEW  
ATD-P-65-74  
N66-12270
- KUBAREV, A. M.  
CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY  
SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY  
LASER  
A65-35866
- CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY  
SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY  
LASER  
A66-19269
- KUBY, W.  
CHEMICAL PUMPING OF LASERS - EYE DAMAGE IN  
MONKEYS FROM LASER IRRADIATION  
U-3259  
N66-1375
- KUCHUBERIA, I. KH.  
MEASURING DEVICE FOR PULSED LASER OUTPUT POWER  
USING BOLOMETER, AMPLIFIER AND OSCILLOSCOPE  
A66-1388
- KUCKUCK, H.  
GALLIUM ARSENIDE LASER DIODES BEHAVIOR AT HIGH  
PULSE RADIATION LOADS  
A65-29354
- KUDREVATOVA, O. V.  
HYDROGEN MOLECULE MULTIPHOTON IONIZATION,  
DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY  
RUBY LASER EMISSION  
A66-16517
- HYDROGEN MOLECULE MULTIPHOTON IONIZATION,  
DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY  
RUBY LASER EMISSION  
A66-20898
- KUHN, R.  
RISE TIME AND OUTPUT POWER OF SINGLE PULSE IN HE-  
NE LASER MEASURED BY METHOD OF CHANGING  
Q-FACTOR BY PLATE LOCATED IN RESONANT CAVITY  
A66-14332
- KULCKE, W.  
USE OF OPTICAL MASERS IN DISPLAYS AND PRINTERS -  
DIGITAL ELECTRO-OPTIC LIGHT DEFLECTOR, CEMENTING  
OF CALCITE CRYSTALS, HIGH SPEED ELECTRONIC  
SWITCHES, AND BIREFRINGENT CRYSTALS  
REPT.-6  
N65-13857
- KULEVSKII, L. A.  
EMISSION SPECTRUM OF RUBY LASER WITH EXTERNAL  
SPHERICAL MIRRORS IN NONDAMPING INTENSITY  
FLUCTUATIONS AND QUASI-STEADY GENERATION  
A65-21041
- CD S SINGLE CRYSTAL OPTICAL GENERATOR DURING  
EXCITATION BY RUBY LASER, DISCUSSING TWO-PHOTON  
ABSORPTION COEFFICIENT AT 300 DEGREES K FOR  
RADIATION FLUX DENSITIES  
A66-13874
- LASER REGIME WITH GIANT PULSES GENERATED IN  
DYSPROSIUM DOPED CALCIUM FLUORIDE UNDER CONTINUOUS  
PUMPING BY XENON LAMPS, OBTAINING Q FACTOR  
MODULATION BY ROTATING PRISM  
A66-19376
- KUMAGAI, N.  
FABRY-PEROT MULTILAYER LASER AMPLIFIER SOLUTIONS  
FROM TRANSIENT THEORY POINT OF VIEW, USING  
LAPLACE TRANSFORM  
A65-29926

- ELECTRIC CIRCUIT ANALOG OPTIMUM DESIGN OF MODE-SELECTIVE MULTIREFLECTOR FABRY-PEROT LASER RESONATORS A65-30344
- MULTIREFLECTOR FABRY-PEROT LASER RESONATORS, DISCUSSING SUPPRESSION EFFECT AGAINST UNWANTED MODES A66-13325
- KUNZE, H.-J.  
LOCAL ELECTRON TEMPERATURE AND ELECTRON DENSITY IN THETA PINCH MEASURED BY MEANS OF SCATTERING OF LASER BEAM A66-14334
- KUO, H.-M.  
SEPARATION OF SINGLE WAVE OSCILLATION MODES OF NEON-HELIUM GAS LASER N65-20782
- KURBATOV, L. M.  
CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION LASER COOLED BY HELIUM GAS FLOW A66-11190
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION LASER COOLED BY HELIUM GAS FLOW A66-24011
- KURNIT, M. A.  
PHOTON ECHO, SHORT PULSE OF LIGHT SPONTANEOUSLY EMITTED BY DILUTE RUBY CRYSTAL AFTER RUBY-LASER PULSE IRRADIATION A66-18442
- KUSHIDA, T.  
WHITE LIGHT EMISSION WHEN PULSED LASER BEAM FOCUSES ON TARGETS IS MAINLY DUE TO TEMPERATURE RADIATION A65-34957
- OPTICAL DOUBLE RESONANCE IN RUBY, DISCUSSING ABSORPTION TRANSITIONS FROM LOWEST EXCITED STATE OF CHROMIUM ION EFFECTED BY LASER PUMPING A66-20856
- KUZNICHEV, V. M.  
PULSE ENERGY AND POWER OF LASERS UNDER CONTINUOUS OPERATING CONDITIONS MEASURED, USING CALORIMETERS, PHOTOELECTRIC EFFECT OF RADIATION, ETC A66-13205
- KUZNETSOV, A. A.  
EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION A65-18558
- EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION A65-27151
- KUZNETSOV, V. S.  
SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-31306
- SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-33352
- L**
- LA MARRE, D. A.  
SUN-POWERED LASER TRANSMITTER DEVELOPMENT - RUBY, NEODYMIUM-DOPED GLASS, AND NEODYMIUM-DOPED CALCIUM TUNGSTATE LASER MATERIALS IER-1 N65-29901
- LA TOURRETTE, J. T.  
NARROW BAND LASER DOPPLER RADAR NAVIGATION INSTRUMENT FOR INSTANTANEOUS GROUND SPEED TRG-019-I-1 N65-27932
- DOPPLER OPTICAL NAVIGATOR TO MEASURE INSTANTANEOUS GROUND SPEED WITH 0.1 FT/SEC ACCURACY FOR ALTITUDES OF 250 TO 5000 FEET - CONTINUOUS WAVE LASER AS TRANSMITTER TRG-019-I-2 N65-28160
- FREQUENCY STABILIZATION IN VISIBLE SPECTRUM OF GAS LASER USED AS OPTICAL PUMP GAIN MODULATOR NASA-CR-64359 N65-31013
- LABEYRIE, A. E.  
TWO-BEAM INTERFEROMETRY BY WAVEFRONT RECONSTRUCTION FROM HOLOGRAM RECORDED WITH COHERENT BACKGROUND SUCCESSIVELY INTERFERE IN SAME LATENT IMAGE A66-23204
- LABUDA, E. F.  
CONSTRUCTION PROBLEMS OF CONTINUOUS-DUTY DC EXCITED ION LASERS A66-13956
- LAFITTE, F.  
PERIODIC VARIATION OF QUALITY FACTOR OF HE-NE GAS LASER CAVITY BY VIBRATING QUARTZ-MODULATION OF LIGHT BEAM A66-13477
- LAIKIN, M.  
OPTICAL COATING REQUIREMENTS OF LASERS WITH RESPECT TO MATERIALS AND MULTILAYER CONFIGURATION A65-29528
- LAINÉ, D. C.  
PULSE EXCITATION OF VOLUME OF GAS TO COHERENTLY RADIATING STATE APPLIED TO BEAM MASER SPECTROMETER A66-23731
- LALLEMAND, P.  
LASER BEAM MULTIMODE EFFECTS AS HINDRANCE TO INTERPRETATION OF QUANTITATIVE MEASUREMENTS OF RAMAN GAIN A65-26958
- LAMB, W. E., JR.  
OPTICAL MASER THEORY INCLUDING OSCILLATORS, RADIATION EMISSION, QUANTUM MECHANICS, ETC A65-24004
- LAMORTE, M. F.  
REABSORPTION AS DOMINANT LOSS MECHANISM FOR BOTH INCOHERENT AND COHERENT RADIATION IN GALLIUM ARSENIDE LUMINESCENT DIODE A65-30347
- TIME RESOLVED SPECTRA FOR PULSE OPERATED GALLIUM ARSENIDE LASER DIODES A65-33372
- HOLE AND ELECTRON SMEARING AND P-TYPE ABSORPTION INFLUENCE ON THRESHOLD CURRENT A66-23478
- LANG, K. R.  
LASER RADIATION EFFECT ON VERTEBRATE EMBRYOS N65-16624
- LANGFORD, R. C.  
INERTIAL SENSORS REVIEWING RING LASER, ELECTROSTATIC FLUID SPHERE, MAGNETIC RESONANCE, SUPERCONDUCTIVITY GYROSCOPE, RELATIVISTIC ROTATING TENSOR, VORTEX RATE AND QUANTUM MECHANICAL EFFECT SENSING AIAA PAPER 65-401 A65-29669
- LARGE, L. N.  
PULSED WATER VAPOR LASER FOR FAR IR GIVING DESIGN AND PERFORMANCE A65-22626
- PULSED GAS LASER FOR FAR INFRARED REGION OF SPECTRUM N65-20170
- LASHER, G. J.  
CURRENT DISTRIBUTION CONTROL IN GALLIUM ARSENIDE INJECTION LASER SHOWING EFFECTS ON OSCILLATION MODE AND THRESHOLD A65-17665
- LAVINE, J. M.  
FABRY-PEROT GALLIUM ARSENIDE LASER HIGHER ORDER AXIAL MODE TEMPERATURE DEPENDENCE A65-17655
- LAVRUSHIN, B. M.  
GALLIUM ARSENIDE LASER EXCITATION BY FAST ELECTRONS A66-22146
- LAWRENCE, J. D., JR.  
MEASUREMENT OF LASER BEAM LIGHT SCATTERED BY ATMOSPHERE NASA-CR-67498 N65-36393
- EARTH ATMOSPHERE PROPERTIES INVESTIGATION BASED ON LASER BEAM BACKSCATTERING MEASUREMENTS NASA-CR-70177 N66-16967

## LAWRENCE, W.

SHOCK TUBE LASER PUMPING - FOUR COMBINATIONS  
OF LASER CRYSTAL AND PUMPING CONFIGURATION  
U-3104 N65-28154

CHEMICAL PUMPING OF LASERS - EYE DAMAGE IN  
MONKEYS FROM LASER IRRADIATION  
U-3259 N66-13799

## LAX, B.

REVIEW OF SEMICONDUCTOR LASER DEVELOPMENTS NOTING  
MAGNETIC EFFECTS, MATERIALS FOR IR COHERENT  
RADIATION, OPTICAL LASER, HOLOGRAPHY, ETC  
A65-30594

## LAYDEN, G. K.

PEROVSKITE LASER HOST MATERIALS HAVING CUBIC  
CENTROSYMMETRIC CRYSTAL LATTICE SITES  
UACRL-D910269-5 N65-35429

## LEBEDEV, I. V.

ELECTRONICS METHODS USED IN LASER TECHNOLOGY AND  
VICE VERSA, EMPHASIZING MICROWAVE PHOTOELECTRONIC  
DEVICES, SELF-CONSISTENT GAS DISCHARGES AT OPTICAL  
FREQUENCIES, ETC A66-20434

EFFECT OF LOAD MISMATCH ON LASER OUTPUT,  
DETERMINING NONLINEAR DEPENDENCE OF EQUIVALENT  
NEGATIVE CONDUCTANCE AS FUNCTION OF OSCILLATION  
AMPLITUDE IN LASER RESONATOR CAVITY  
A66-20435

## LEBEDEV, O. L.

RUBY LASER OUTPUT RADIATION CHANGE DUE TO  
PHthalOCYANINE SOLUTIONS PLACED IN RESONATOR  
CAVITY A65-21071

GIANT LASER EMISSION PULSES IN NEODYMIUM ACTIVATED  
GLASS ROD BY VARYING CAVITY Q WITH QUINOLINE  
SOLUTION OF POLYMETHINE DYE A65-27554

RUBY LASER OUTPUT RADIATION CHANGE DUE TO  
PHthalOCYANINE SOLUTIONS PLACED IN RESONATOR  
CAVITY A65-31236

## LEBEDEVA, V. V.

EFFECT OF LOAD MISMATCH ON LASER OUTPUT,  
DETERMINING NONLINEAR DEPENDENCE OF EQUIVALENT  
NEGATIVE CONDUCTANCE AS FUNCTION OF OSCILLATION  
AMPLITUDE IN LASER RESONATOR CAVITY  
A66-20435

## LEBLOCH, H.

STIMULATED EMISSION IN INDIUM ARSENIDE SHOWS  
EXCITATION THRESHOLD LOW AND LIGHT EMISSION HIGHLY  
DIRECTIONAL A66-17026

## LEDGER, W.

LOW FREQUENCY MAGNETIC FIELD SENSOR - PROTON  
MASER ANTENNA DESIGN CONSTRUCTION AND  
PERFORMANCE  
RADC-TR-64-567 N65-32211

## LEDGER, A. M.

STANDING WAVES IN LASER RESONATORS VERIFIED BY  
PLACING THIN METALLIC FILMS BETWEEN EXTERNAL  
MIRRORS OF PULSED NEODYMIUM LASER  
A66-22893

## LEE, T.-C.

QUANTUM MECHANICAL TREATMENT OF MOLECULAR  
RADIATION BEHAVIOR IN DETUNING CAVITY OF DOUBLE  
CAVITY MASER  
FTD-TT-65-888/1&2&3&4 N66-19899

## LEE, Y. C.

QUANTUM THEORY OF INTERACTION OF ELECTROMAGNETIC  
WAVES IN PLASMA CONSIDERED IN TERMS OF LIGHT-  
LIGHT SCATTERING AND PLASMA-LASER BEAM INTERACTION  
A66-21173

## LEFEBVRE, M.

IMPROVEMENT OF FORECASTS AND ANALYSIS OF LASER  
MEASUREMENTS FOR SATELLITE S-66  
NASA-TT-F-8772 N66-11607

## LEGATO, T.

EXCITATION OF RUBY LASERS USING DOUBLE-PUMPED  
HIGH-INTENSITY HELICAL FLASH TUBES, OBTAINING

TIME-RESOLVED SPECTRA OF ELECTRICAL DISCHARGES AND  
PLASMA TEMPERATURES A66-11446

## LEHMANN, R.

SPECTROSCOPIC DATA ON ABSORPTION, SPONTANEOUS  
FLUORESCENCE AND STIMULATED EMISSION IN ACTINIDES,  
TRANSITION METAL AND SEMICONDUCTOR LASER MATERIAL  
A65-21168

## LEITE, R. C. C.

BUILDUP AND DECAY TRANSIENT EFFECTS IN GAS LASERS  
DUE TO LIGHT ABSORPTION BY INSERTED LIQUID SAMPLES  
A65-15816

## LEITH, E. N.

COHERENT LASER LIGHT USED IN NEW PHOTOGRAPHIC  
PROCESS FOR RECORDING LIGHT WAVES INSTEAD OF IMAGE  
ON LIGHT-SENSITIVE FILM A65-28104

## LEMPICKI, A.

LASER ACTION IN RARE EARTH CHELATES, EMPHASIZING  
CHEMISTRY AND SPECTROSCOPIC PROPERTIES OF  
MATERIALS AND PROPERTIES OF LIQUID LASER  
A65-20074

EMISSION SPECTRA OF TRIS AND TETRAKIS FORMS OF  
FOUR BETA-DIKETONE EUROPIUM CHELATES STUDIED FOR  
LIQUID LASER APPLICATION A65-33308

CHELATE LASER SYSTEMS - EUROPIUM BENZOYLACETONATE  
TR-64-052.7 N65-14405

ORGANIC LASER DEVELOPMENT N65-15503

RARE EARTH CHELATE LASERS N65-15508

EMISSION SPECTROSCOPY AND COORDINATION CHEMISTRY  
OF EUROPIUM CHELATE SOLUTIONS - CHELATE LASERS  
INVESTIGATED FOR EVALUATING POTENTIALITIES OF  
LIQUID LASERS  
TR-65-052-11 N66-14177

COORDINATION AND CHEMICAL EQUILIBRIUM IN CHELATE  
LASER MATERIALS N66-20730

## LEONARD, D. A.

LASER ACTION IN SECOND POSITIVE BAND SYSTEM OF  
MOLECULAR NITROGEN, OBSERVING SATURATION OF  
TRANSITION A65-33049

LASER ACTION AT 5401 ANGSTROMS IN PURE NEON PULSED  
HIGH VOLTAGE DISCHARGE A66-10353

## LEONTOVICH, A. M.

HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE  
EXCITATION AND GENERATION KINETICS IN RUBY LASER  
WITH CONCENTRIC CAVITY A65-18460

CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL  
RUBY CRYSTALS DUE TO HEATING BY EXCITING LIGHT  
A65-18461

HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE  
EXCITATION AND GENERATION KINETICS IN RUBY LASER  
WITH CONCENTRIC CAVITY A65-28089

CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL  
RUBY CRYSTALS DUE TO HEATING BY EXCITING LIGHT  
A65-28090

H F MODULATION OF RADIATION SPIKES DUE TO BEATS  
BETWEEN OSCILLATION MODES IN OPTICAL RUBY LASER  
A65-31701

RUBY LASER WITH CONCENTRIC RESONATOR AS  
ILLUMINATION SOURCE OF BUBBLE CHAMBER  
A66-11189

H F MODULATION OF RADIATION SPIKES DUE TO BEATS  
BETWEEN OSCILLATION MODES IN OPTICAL RUBY LASER  
A66-19955

RUBY LASER WITH CONCENTRIC RESONATOR AS  
ILLUMINATION SOURCE OF BUBBLE CHAMBER  
A66-24010

## LEROUX-HUGON, P.

STIMULATED EMISSION IN INDIUM ARSENIDE SHOWS  
EXCITATION THRESHOLD LOW AND LIGHT EMISSION HIGHLY

- DIRECTIONAL A66-17026
- LESNICK, J. P.  
EFFICIENT CONVERSION OF ELECTRICAL ENERGY INTO  
LASER RADIATION, USING COAXIAL OPTICAL PUMP A66-23479
- LESPERANCE, F. A., JR.  
RETINAL VASCULATURE OF RABBIT AND MONKEY AS  
AFFECTED BY LASER IRRADIATION PROXIMITY OF  
PIGMENT EPITHELIUM, BLOOD FLOW, AND AMOUNT OF  
REDUCED HEMOGLOBIN A66-80470
- LETOKHOV, V. S.  
OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER  
BY P-N TRANSITIONS TO INCREASE POWER AND  
DIRECTIVITY OF EMISSION A65-17319
- LASER OSCILLATION FREQUENCY AND AMPLITUDE  
FLUCTUATIONS MEASURED BY DELAY LINE AND SQUARE LAW  
DETECTOR A65-20510
- EXPERIMENTAL PROCEDURE TO MEASURE PROBABILITY  
DENSITY AMPLITUDE OF ELECTRIC COMPONENT OF LASER  
RADIATION FIELD A65-21070
- LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO  
DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF  
SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS  
A65-24879
- SYNCHRONIZED MODE OF EXCITATION FOR DIFFRACTION-  
COUPLED LASER A65-28538
- OSCILLATIONS SYNCHRONIZED IN SEMICONDUCTOR LASER  
BY P-N TRANSITIONS TO INCREASE POWER AND  
DIRECTIVITY OF EMISSION A65-30372
- EXPERIMENTAL PROCEDURE TO MEASURE PROBABILITY  
DENSITY AMPLITUDE OF ELECTRIC COMPONENT OF LASER  
RADIATION FIELD A65-31235
- SYNCHRONIZED GENERATION OF RADIATION BY ALL  
SEMICONDUCTOR ELEMENTS OF LASER SYSTEM WITH  
RADIATIVE MIRRORS CAUSED BY DIFFRACTION OF  
ELECTROMAGNETIC FIELD A65-35279
- LIMITS ON CROSS SECTION OF CW LASER BEAM DUE TO  
DELAYED INTERACTION IN FAR FIELDS OR MISMATCH OF  
SELF-RESONANT FREQUENCIES OF RESONATOR COMPONENTS  
A65-36356
- ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION  
INVERSION IN LEVELS OF OPTICAL TRANSITION A66-10448
- SHARPLY DIRECTIONAL COHERENT RADIATION GENERATION  
BY SYNCHRONIZED LASERS OR MULTIMIRRORED RESONATOR  
OF SINGLE LASER A66-11007
- SYNCHRONIZED MODE OF EXCITATION FOR DIFFRACTION-  
COUPLED LASER A66-12293
- ATOMIC BEAM LASERS, PARTICULARLY FOR POPULATION  
INVERSION IN LEVELS OF OPTICAL TRANSITION A66-13311
- PROPAGATION RATE OF HIGH POWER LASER LIGHT PULSE  
IN INVERSELY POPULATED MEDIUM A66-15333
- SHARPLY DIRECTIONAL COHERENT RADIATION GENERATION  
BY SYNCHRONIZED LASERS OR MULTIMIRRORED RESONATOR  
OF SINGLE LASER A66-19945
- NONLINEAR AMPLIFICATION OF LIGHT PULSE PASSING  
THROUGH LASER OPERATING AT SATURATION REGIME A66-21963
- LEVINE, L. P.  
INTERACTION MECHANISM BETWEEN LASER BEAM AND  
SURFACE IN ULTRAHIGH VACUUM A66-15484
- LEVITT, R. S.  
SELF-INDUCED OSCILLATIONS IN OUTPUT OF FABRY-  
PEROT GALLIUM ARSENIDE INJECTION LASER A65-21624
- LEVKOEY, I. I.  
PENTACARBOCYANINE COMPOUND USED TO REDUCE
- PONCPULSE DURATION IN NEODYMIUM LASER A66-10262
- PENTACARBOCYANINE COMPOUND USED TO REDUCE  
MONOPULSE DURATION IN NEODYMIUM LASER A66-13307
- LEWIS, A. L.  
LASER BEAM AMPLIFICATION BY REFLECTION FROM  
SCANNING GAS LASER ACTIVE INTERFEROMETER A65-33047
- GAIN AND BANDWIDTH NARROWING IN REGENERATIVE  
HELIUM-XENON LASER AMPLIFIER A66-12308
- INFRARED SPECTRUM, OPTICAL PROPERTIES, AND  
FABRICATION OF EIGHT-METER GAS LASER  
NEL-1242 N65-14446
- LEWIS, B. L.  
PHOTON TRAPPED WAVE EFFECT FOR DEVELOPING OPTICAL  
WAVEGUIDES IN WHICH OPTICAL BEAM CREATES WAVEGUIDE  
AS IT PROPAGATES A66-16662
- LEWIS, R. D.  
LASER DOPPLER FLOWMETER MEASUREMENT TECHNIQUE  
FOR LOCALIZED FLOW VELOCITIES IN GAS, NOTING  
RELIABILITY FOR HIGH FLOW VELOCITIES A65-35061
- LASER FLOW METER FOR MEASUREMENT OF LOCAL VELOCITY  
IN CONTAMINATED GAS FLOW FIELDS - DOPPLER SHIFT  
TECHNIQUE R-149 N65-26015
- LI, C.-F.  
TRANSMISSION CHARACTERISTICS OF NEODYMIUM LASER  
N66-16812
- LI, H.-S.  
TRANSMISSION CHARACTERISTICS OF NEODYMIUM LASER  
N66-16812
- LI, S.-Y.  
OPTICAL MASER OF TRIVALENT NEODYMIUM IN TUNGSTATE  
CRYSTALS N66-15045
- LI, T.  
DIFFRACTION LOSSES, PHASE SHIFTS AND FIELD  
DISTRIBUTION FUNCTIONS FOR TWO LOWEST-ORDER MODES  
ON INTERFEROMETER-TYPE MASER RESONATORS WITH  
CIRCULAR MIRRORS A65-24911
- SINGLE-MODE SELECTION AND MODE VOLUME ENHANCEMENT  
IN HE-NE GAS LASER WITH INTERNAL LENS A65-26820
- LI, T.-C.  
COHERENT AND INCOHERENT OUTPUT CURVE OF THREE-  
LEVEL QUANTUM FREQUENCY CONVERTER A65-17505
- PHOTON TRANSPORT AND POPULATION INVERSION IN  
ACTIVE MEDIUM WITH PUMPING EFFECT, CONSIDERING  
INTENSE BEAM INCIDENCE AND RUBY LASER A65-36712
- LIANG, P.-K.  
OPTICAL MASER OF TRIVALENT NEODYMIUM IN TUNGSTATE  
CRYSTALS N66-15045
- LICHTBLAU, G. J.  
BALLOON-BORNE XENON LIGHT OPTICAL BEACON FOR  
LASER AND OPTICAL TRACKING, AND MISSILE-BORNE  
XENON OPTICAL BEACON FOR OPTICAL TRACKING  
B-3068 N65-31897
- LIGDA, M. G. H.  
AIRBORNE LASER-RADAR LIGHT DETECTION AND RANGING  
/ LIDAR/ SYSTEMS APPLIED TO DETECTION OF CLEAR AIR  
TURBULENCE / CAT/ A66-15297
- LIGHT, J. C.  
CHEMICAL PROCESSES PRODUCING SPECTROSCOPICALLY  
OBSERVABLE POPULATION INVERSIONS IN ATOMIC OR  
MOLECULAR LASERS A65-20066
- LIN, C.-C.  
STIMULATED EMISSION OF LIGHT FROM PURE XENON AND

- HELIUM-XENON N65-20135
- HELIUM-NEON LASER WITH SILVER AND DIELECTRIC COATING N65-20136
- LIN, F.-C.**  
FORMATION OF MICROWAVE MASER BY PUMPING OF LOW TEMPERATURE RUBY LASER N66-15049
- LINARES, R. C.**  
GROWTH OF NEW CRYSTAL MATERIALS FOR LASERS - SPECTRAL ANALYSIS USING FLAME FUSION, CZOCHRALSKI, FLUX, AND VAPOR TECHNIQUES M7881 N65-19354
- LINN, J.**  
EFFECT OF NONUNIFORM SPATIAL INTERACTION BETWEEN MODES ON TEMPORAL AND SPATIAL OUTPUT OF RUBY LASER A65-33415
- LIPNICK, R.**  
LARGE-ANGLE NONMECHANICAL SCANNING OF LIGHT IN ONE AND TWO DIMENSIONS THROUGH OPTICAL REFRACTION BY TRAVELING ACOUSTIC WAVES A65-21326
- LISITSIN, V. N.**  
RUBY CRYSTAL OPTICAL PROPERTIES INVESTIGATED BY INTERFERENCE RINGS FROM REFLECTING HE- NE LASER BEAM FROM CRYSTAL FACE A66-11045
- RUBY CRYSTAL OPTICAL PROPERTIES INVESTIGATED BY INTERFERENCE RINGS FROM REFLECTING HE- NE LASER BEAM FROM CRYSTAL FACE A66-23292
- LITTLE, J. A.**  
REFLECTION COEFFICIENT OF CAVITY TUBING AS EXPLANATION FOR POWER LEVEL OF HELIUM-NEON IR FABRY- PEROT INTERFEROMETER A65-30342
- LIU, C.-S.**  
OPTICAL COMMUNICATION SYSTEMS - LASER THEORY AND APPLICATION TO COMMUNICATIONS FTO-TT-65-95/1626364 N66-12120
- LIU, S.-F.**  
OPTICAL MASER OF TRIVALENT NEODYMIUM IN TUNGSTATE CRYSTALS N66-15045
- LIU, S.-H.**  
SOLID STATE LASERS - PROBLEMS OF CONTINUOUS STIMULATED EMISSION IN SOLIDS, MATERIALS, LIGHT SOURCES, COOLING, AND APPLICATIONS N65-36116
- LIU, W.-L.**  
STIMULATED EMISSION FROM GALLIUM ARSENIC P-N JUNCTION LASERS N65-20780
- LIUBIMOV, V. V.**  
THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE LOSSES IN FABRY- PEROT RESONATORS DUE TO MIRROR MISALIGNMENT A65-36053
- THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE LOSSES IN FABRY- PEROT RESONATORS DUE TO MIRROR MISALIGNMENT A66-15856
- LIUMAROV, E. N.**  
TREATMENT OF STEEL WITH LASER BEAM, OBTAINING PRECISION HOLES WITHOUT AFFECTING MICROHARDNESS OF METAL A66-24898
- LIUSTROV, I. U. M.**  
CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION LASER COOLED BY HELIUM GAS FLOW A66-11190
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION LASER COOLED BY HELIUM GAS FLOW A66-24011
- LIVSHITS, B. L.**  
GENERATION OF INDUCED LASER RADIATION IN PRESTATIONARY REGIME A66-17877
- LO CASCIO, C.**  
MULTIPLE REFLECTION THEORY APPLIED TO REGENERATIVE LASER AMPLIFIER DESIGN ECOM-2531 N65-19166
- REGENERATIVE RUBY LASER AMPLIFIERS AT LIQUID NITROGEN TEMPERATURES ECOM-2575 N65-35642
- LOCASCIO, C.**  
RUBY LASER AMPLIFIER AT LIQUID-NITROGEN TEMPERATURE TREATED AS THREE-MEDIUM TRANSMISSION SYSTEM, NOTING GAIN CHANGE WITH NEGATIVE ATTENUATION A66-22867
- LONG, L. T.**  
PHOTOTUBE OBSERVATION OF RUBY LASER OUTPUT AS FUNCTION OF TIME N65-15570
- LORIERS, J.**  
PREPARATION OF SINGLE CRYSTALS OF DOUBLE MOLYBDATES OF NA AND LA /OR OTHER RARE EARTH ELEMENTS/ DOPED WITH ND, TB OR PR FOR LASER APPLICATION A66-13478
- LOTSCH, H. K. V.**  
RESONANT WAVES IN FABRY- PEROT INTERFEROMETER INVESTIGATED ON BASIS OF STANDING WAVE TYPE FORMULATION A65-33516
- INTENSITY DISTRIBUTION IN FABRY- PEROT INTERFEROMETER PRODUCING RESONANT WAVES FOR LARGE FRESNEL NUMBER APPLIED IN MODEL FOR FILAMENT-FORM LASER MECHANISM A66-13097
- FABRY- PEROT INTERFEROMETER AND CONFOCAL AND SPHERICAL RESONATOR, CALCULATING INTEGRAL EQUATIONS FOR EIGENVALUE AND EIGENFUNCTION OF LOWEST ORDER TW EIGENMODE A66-14277
- SOLID STATE LASER OUTPUT EXHIBITING REGULAR AND IRREGULAR SPIKES ANALYZED THROUGH RELAXATION OSCILLATIONS AND CLASSICAL PHYSICS A66-20568
- LOVE, J. A., III**  
COMPUTER ANALYSIS DETERMINING CHANGE OF POPULATION INVERSION AND OUTPUT PHOTON FLUX AND EXPERIMENT USING RUBY FOR OSCILLATOR AND AMPLIFIER USING TRAVELING WAVE MASER IN TRIANGULAR CONFIGURATION GSP/PHYS/65-14 N65-31091
- LOVISETTO, L.**  
MULTICHANNEL PHOTOELECTRIC SPECTRUM ANALYZER WITH KERR CELL GATING RECORDS SPECTRUM OF LASER LIGHT SCATTERED FROM SINGLE GIANT PULSE IN PLASMA A65-28203
- LOZHNIKOV, A. A.**  
LOCAL LASER HEATING OF CATHODE FOR ELECTRON EXTRACTION FROM PLASMOID A66-16149
- LU, S.**  
POLARIZATION OF LIGHT FROM GLASS LASER DOPED WITH TWO PERCENT POSITIVE TRIVALENT NEODYMIUM MEASURED WITH TIME RESOLUTION OF LESS THAN MICROSECOND A66-13006
- LUCY, R. F.**  
OPTICAL SUPERHETERODYNE RECEIVER - LASER SYSTEM, DOPPLER FREQUENCY TRACKING, AND OPTICAL TRACKING NASA-CR-63393 N65-26401
- LUIZOVA, L. A.**  
EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS BY INCLINING GENERATING SAMPLE WITH RESPECT TO INTERFEROMETER AXIS A65-18454
- EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS BY INCLINING GENERATING SAMPLE WITH RESPECT TO INTERFEROMETER AXIS A65-28083
- LUPACHEV, E. P.**  
LASER OSCILLATION IN CALCIUM TUNGSTATE CRYSTALS ACTIVATED WITH TRIVALENT PRASEODYMIUM A66-14898

## M

- MAAS, P. M.**  
LASER BEAM WELDING ELECTRONIC-COMPONENT LEADS A66-14517



- MAC KENZIE, L. A.**  
LINEAR BEAM AND MICROWAVE POWER GENERATION - BEAM-CIRCUIT INTERACTION, BASIC CIRCUITS, BEAM-PLASMA AMPLIFIER, AND LASER-STIMULATED THERMIONIC EMISSION  
RADC-TR-65-22 N65-27099
- MACAVOY, T. C.**  
GLASS COMPOSITION EFFECT ON SPECTRAL PROPERTIES OF ND-DOPED GLASSES AND SELECTING ONE FOR LASER GLASS  
A65-17635
- MACÉ, P. M.**  
OPTICAL PUMP PULSE SHAPE EFFECT ON POPULATION INVERSION ATTAINED IN RUBY LASER  
A65-16569
- MACFARLANE, G. G.**  
LASER DEVELOPMENT, DISCUSSING BASIC THEORY, PUMPING METHODS AND LASER TYPES  
A66-18700
- MACKE, B.**  
OPTIMUM LASER CAVITY STRUCTURES USING MATRIX CALCULATIONS BASED ON GEOMETRICAL OPTICS APPROXIMATION  
A65-23846
- MADEVAN, D.**  
RUBY LASERS DISCUSSING OUTPUT CHARACTERISTICS, BEAM DIVERGENCE, BEAT MODES AND RESPECTIVE EXPERIMENTAL TECHNIQUES  
A66-14919
- MAGDICH, L. M.**  
STATIC CHARACTERISTICS OF GAS LASER INTERNAL MODULATION CIRCUIT, USING ELECTRO-OPTICAL CRYSTAL INSERTED INTO GAS LASER RESONATOR  
A66-14059
- MAHR, H.**  
DECAY OF F-CENTER EXCITATIONS IN ALKALI HALIDES INDUCED BY SHORT INTENSE PULSE OF Q-SWITCHED RUBY LASER  
A66-19367
- DECAY OF LASER-INDUCED EXCITATIONS OF F CENTERS IN ALKALI HALIDES  
MSC-387 N65-34867
- EXCITED STATE SPECTROSCOPY USING RUBY LASER AND LOCALIZED EXCITONS IN ALKALI HALIDES  
AD-619198 N65-35423
- MAHAM, T. M.**  
LASER FUTURE POSSIBILITIES AND APPLICATION CONSIDERING OPTICALLY PUMPED SOLIDS, SEMICONDUCTORS AND ANCILLARY EQUIPMENT  
A65-21954
- MAIN, W. F.**  
PHYSICAL ELECTRONICS, SOLID STATE PHYSICS, LIQUID STATE PHYSICS, INFORMATION SCIENCES, AND LASER AND COMMUNICATION THEORY  
LMSC-6-75-65-10 N65-25125
- MAIO, A. D.**  
THERMAL DISTORTION, EXPANSION AND SCATTERING IN RUBY AND GLASS LASER RODS DURING AND AFTER PUMP FLASH  
A65-35068
- MAK, A. A.**  
STATIONARY AND TRANSIENT LIGHT AMPLIFICATION REGIMES IN ACTIVE MEDIA OPERATING ACCORDING TO FOUR-LEVEL SCHEME  
A65-18455
- STATIONARY AND TRANSIENT LIGHT AMPLIFICATION REGIMES IN ACTIVE MEDIA OPERATING ACCORDING TO FOUR-LEVEL SCHEME  
A65-28084
- SINGLE PULSE OPERATION OF LASERS, NOTING ENERGY STORAGE AND AMPLIFICATION EFFECT FOR FOUR- AND THREE-LEVEL ACTIVE MEDIUM  
A66-23667
- MAKER, P. D.**  
NONLINEAR OPTICAL EFFECTS IN CRYSTALLINE AND ISOTROPIC MATERIALS DUE TO INDUCED POLARIZATION THIRD ORDER IN ELECTRIC FIELD STRENGTH, USING GIANT PULSED LASER SOURCE  
A65-16863
- MAKHORIN, V. I.**  
HELIUM-NEON LASER RADIATION DISPERSION MEASUREMENT IN TRANSITION 3S2-2P4 FOR VARYING MIRROR SPACING  
A65-19693
- RADIATION DIVERGENCE MEASUREMENT IN HELIUM-NEON LASERS WITH CONFOCAL RESONATORS AND SPHERICAL REFLECTORS  
N65-24550
- MAKSIKOVA, G. V.**  
CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH NEODYMIUM IONS  
A65-31703
- CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH NEODYMIUM IONS  
A66-19956
- MALACARA, D.**  
TWO LENSES WITH FOCAL RATIOS OF F/4 AND F/2.65 USED TO COLLIMATE LIGHT FROM HELIUM-NEON LASER  
A66-14921
- MALAMUD, H.**  
GAS LASER INTERFEROMETERS FOR PLASMA LOW ELECTRON DENSITY MEASUREMENT  
A66-10856
- MALEIN, A.**  
FREQUENCY RESPONSE AND CROSS COUPLING OF RED AND IR GAS LASER INTERFEROMETER FOR MEASURING PLASMA ELECTRON DENSITY  
A65-15819
- MALYSHEV, G. M.**  
SOVIET AND FOREIGN PAPERS ON PLASMA DIAGNOSTICS BY SCATTERING OF LASER BEAMS AT PLASMA ELECTRONS  
A66-21990
- MALYSHEV, V. I.**  
Q-SWITCHING OF ND LASER USING POLYMETHINE DYE IN METHYL ALCOHOL SOLVENT  
A65-27533
- PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER  
A66-10262
- PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER  
A66-13307
- GAS LASER OUTPUT AND THRESHOLD IN POPULATION INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE AND FLUORO IODO METHYLIDYNE  
A66-16771
- DEPENDENCE OF BEAT FREQUENCY OF NEODYMIUM LASER AXIAL MODES ON DISTANCE BETWEEN MIRRORS AND NEODYMIUM ROD POSITION WITHIN RESONATOR  
A66-24881
- MANEZADE, S. M.**  
RESONANCE OSCILLATION IN RUBY LASER EMISSION STUDIED BY FABRY-PEROT MULTIPLEX ETALON AS FUNCTION OF RESONATOR PROPERTIES  
A65-24976
- MULTIPLE LIGHT FILTER NARROWING EMISSION BANDS OF RUBY LASER WITH MULTIPLEX RESONATOR  
A66-12627
- MULTIPLEX LIGHT FILTER FOR EXCITATION OF RUBY LASER  
A66-22032
- RUBY LASER RADIATION SPECTRUM AND OPTICAL RESONANCE AT ROOM TEMPERATURE  
FTD-TT-65-1312/16264 N66-19914
- MANCINI, M.**  
PEAK POWER TRANSIENTS OF NEAR CONFOCAL HELIUM-NEON LASER WORKING AT 6328 ANGSTROMS ON PULSED DISCHARGE BASIS  
A66-10329
- MANDEL, L.**  
QUANTUM THEORETICAL ANALYSIS OF LASER BEAM FLUCTUATIONS AND OF LIGHT BEAT EXPERIMENTS WITH TWO LASERS  
A65-25059
- MANDELSHTAM, S. L.**  
SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF PULSED RUBY LASER OUTPUT  
A65-14131
- SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF PULSED RUBY LASER OUTPUT  
A65-24951

- SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER RADIATION, DETERMINING TEMPERATURE OF PLASMA PRODUCED NEAR FOCUS A65-31705
- SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER RADIATION, DETERMINING TEMPERATURE OF PLASMA PRODUCED NEAR FOCUS A66-19959
- MANDICS, P.**  
COHERENT LASER BEAM USED TO SHOW CCNSTANCY OF VELOCITY OF ELECTROMAGNETIC RADIATION A65-14215
- MANENKOV, A. A.**  
TRANSITION PROCESSES OF OSCILLATION AMPLITUDE FORMATION IN RF THREE-LEVEL MASERS A65-15460
- TRANSITION PROCESSES OF OSCILLATION AMPLITUDE FORMATION IN RF THREE-LEVEL MASERS A65-28556
- CONCENTRATION AND TEMPERATURE DEPENDENCE OF SPIN-LATTICE RELAXATION TIME IN RUBY AT HELIUM TEMPERATURES A66-18257
- CONCENTRATION AND TEMPERATURE DEPENDENCE OF SPIN-LATTICE RELAXATION TIME IN RUBY AT HELIUM TEMPERATURES A66-20901
- MANGER, H.**  
QUASI-CONTINUOUS OPERATION OF CALCIUM TUNGSTATE/NEODYMIUM ION MASER USING LONG DURATION PUMPING PULSES A65-16575
- MANINGER, C.**  
LASER BEAM DEFLECTION MODULATION OBTAINED BY PASSING CURRENT THROUGH CADMIUM SULFIDE PRISM WITH OHMIC CONTACTS, USED FOR THERMOCOUPLE MEASUREMENTS A65-25890
- MANYKIN, E. A.**  
SECOND HARMONIC LIGHT GENERATION IN CADMIUM SULFIDE CRYSTAL NEAR ABSORPTION BAND A65-21056
- SECOND HARMONIC LIGHT GENERATION IN CADMIUM SULFIDE CRYSTAL NEAR ABSORPTION BAND A65-31220
- MARCUS, I. R.**  
DIGITAL TIME-INTERVAL COUNTER /RANGEMETER/ FOR USE WITH LASER RANGEFINDER HDL-TR-1262 N65-14460
- MARCUSE, D.**  
NOISE OUTPUT AND NOISE FACTOR OF OVERLOADED MASER AMPLIFIERS STUDIED AS FUNCTION OF SMALL-SIGNAL GAIN VS ACTUAL GAIN A65-31032
- MARCY, R.**  
PHOTOELECTRONS EMITTED BY PHOTOCATHODE LIT BY HEAT SOURCE AND LASER COUNTING NUMBER OF AVALANCHES DURING GIVEN TIME A65-18037
- ULTIMATE SENSITIVITY LIMIT AND PHOTOELECTRON STATISTICS FOR PHOTOMULTIPLIER LIT BY COHERENT AND NONCOHERENT LIGHT A66-12473
- MARGUIN, J.**  
PHOTOELECTRONS EMITTED BY PHOTOCATHODE LIT BY HEAT SOURCE AND LASER COUNTING NUMBER OF AVALANCHES DURING GIVEN TIME A65-18037
- ULTIMATE SENSITIVITY LIMIT AND PHOTOELECTRON STATISTICS FOR PHOTOMULTIPLIER LIT BY COHERENT AND NONCOHERENT LIGHT A66-12473
- MARIE, G.**  
LIGHT MODULATION AND LASER TELECOMMUNICATIONS NASA-TT-F-8762 N65-32178
- MARINACE, J. C.**  
CURRENT DISTRIBUTION CONTROL IN GALLIUM ARSENIDE INJECTION LASER SHOWING EFFECTS ON OSCILLATION MODE AND THRESHOLD A65-17665
- GA AS OPTICALLY COUPLED TRANSISTOR STRUCTURE WITH LASING EMITTER A66-12442
- MARKIN, A. S.**  
Q-SWITCHING OF ND LASER USING POLYMETHINE DYE IN METHYL ALCOHOL SOLVENT A65-27533
- PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER A66-10262
- PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER A66-13307
- DEPENDENCE OF BEAT FREQUENCY OF NEODYMIUM LASER AXIAL MODES ON DISTANCE BETWEEN MIRRORS AND NEODYMIUM ROD POSITION WITHIN RESONATOR A66-24881
- MARKIN, E. P.**  
LASER OUTPUT OF XENON-HELIUM MIXTURE AS FUNCTION OF CHARGE DURATION, GAS PRESSURE AND TUBE DIAMETER A65-20263
- EXPERIMENTAL PROCEDURE TO MEASURE PROBABILITY DENSITY AMPLITUDE OF ELECTRIC COMPONENT OF LASER RADIATION FIELD A65-21070
- EXPERIMENTAL PROCEDURE TO MEASURE PROBABILITY DENSITY AMPLITUDE OF ELECTRIC COMPONENT OF LASER RADIATION FIELD A65-31235
- MARKOWSKA, E.**  
HOMOGENEITY AND DIFFUSION LENGTH OF MINORITY CARRIERS IN SEMICONDUCTORS MEASURED, USING LASER BEAM A65-33809
- MARSHALL, T.**  
MAGNETIC FIELD PROBE IN ELECTROMAGNETICALLY DRIVEN SHOCK TUBE AND COHERENT LIGHT IN IONIZING SHOCK WAVE PLASMA DIAGNOSTICS A65-29569
- MARSHALL, T. C.**  
GAS LASER CROSS MODULATION EFFECT WHEN EXPOSED TO FLASH TUBE RADIATION A65-15324
- TIME DEVELOPMENT OF OUTPUT INTENSITY OF HE- NE LASER AFTER QUENCHING BY PUMPING PARTICLES INTO LOWER NEON LASER STATE A65-29075
- MARSTEN, R. B.**  
SYSTEMS ANALYSIS OF LASERS VS MICROWAVES FOR MARS-TO- EARTH COMMUNICATIONS IN 1970 A65-28248
- SPACE COMMUNICATION REQUIREMENTS USING LASERS AND MICROWAVES IN MANNED MARS FLIGHTS AIAA PAPER 65-324 A65-30519
- MARTIN, E. P.**  
CONCEPTUAL MODEL OF BACKSCATTERED FIELD OF LASERS AND USE FOR ROTATION DETECTION GE/EE/65-13 N66-16473
- MARTIN, L. J.**  
LASER WELDING FOR PRODUCTION MICROWELDING, NOTING DESIGN, CONSTRUCTION AND APPLICATION ASTME PREPRINT MM66-707 A66-24415
- LASER TECHNIQUES FOR WELDING POLYTHERMALESE COATED MAGNET WIRE TO STAINLESS STEEL AND GOLD PLATED NICKEL TERMINALS NASA-CR-70935 N66-19615
- MARTINELLI, R. U.**  
EMISSION AND ABSORPTION PROFILES FOR RUBY R SUB 1 LINES SHOW ABSENCE OF SIGNIFICANT STOKES SHIFT A65-17664
- C W LASER ACTION ON TRIPLE STATE PHOSPHORUS-SULFUR TRANSITION, USING HYDROGEN SULFIDE-NOBLE GAS MIXTURES A66-21577
- MARTIROSIAN, R. M.**  
MASER AMPLIFIER WITH COUPLED ACTIVE RESONATORS OPERATING AT 21 CM WAVELENGTH, NOTING ADVANTAGE OVER PASSIVE INPUT CIRCUIT A65-14136
- TRANSITION PROCESSES OF OSCILLATION AMPLITUDE FORMATION IN RF THREE-LEVEL MASERS A65-15460

- MASER AMPLIFIER WITH COUPLED ACTIVE RESONATORS OPERATING AT 21 CM WAVELENGTH, NOTING ADVANTAGE OVER PASSIVE INPUT CIRCUIT A65-24011
- TRANSITION PROCESSES OF OSCILLATION AMPLITUDE FORMATION IN RF THREE-LEVEL MASERS A65-28556
- MARUSHKO, I. A.  
SECOND HARMONIC GENERATION BY LASER BEAMS OF FINITE SPECTRAL WIDTH, USING QUANTUM TRANSITIONS AND KINETIC EQUATIONS, NOTING SHAPE OF PUMPING LINE AT FUNDAMENTAL FREQUENCY A66-22026
- MARUSHKO, I. G.  
ELECTROMAGNETIC FIELD AND SECOND OPTICAL HARMONIC GENERATED IN LASER RESONATOR AS TWO INTERDEPENDENT PROCESSES A65-25271
- MAS, G.  
INTERFERENCE PHENOMENON OF SERRATED SYSTEM OF RINGS SURROUNDING CENTRAL BEAM OF GAS LASER ANALYZED, USING HELIUM NEON TUBE PLACED BETWEEN TWO EXTERIOR MIRRORS A66-17064
- MASH, D. I.  
XENON-KRYPTON LASER EMISSION IN 12 WAVELENGTHS RANGING FROM 2.03 TO 9 MICRONS WITH EXTERNAL AND INNER MIRRORS A65-17353
- EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION A65-18558
- EMISSION AND GAS MIXTURE PRESSURE RELATIONSHIP FOR HELIUM-XENON LASER OPERATING IN CENTRAL IR REGION A65-27151
- BEAM DIVERGENCE ANGLE OF SINGLE TEM MODE NE- HE LASER OUTPUT AT 0.63 MICRONS A65-27739
- BEAM DIVERGENCE ANGLE OF SINGLE TEM MODE NE- HE LASER OUTPUT AT 0.63 MICRONS A65-31844
- MASHKEVICH, V. S.  
KINETIC EQUATION TO DESCRIBE CONTINUOUS WAVE LASER RADIATION INSTABILITY A65-19739
- MINIMUM VALUE OF TIME DEPENDENT LASER RADIATION LOSSES AT WHICH GIANT OSCILLATIONS OCCUR A65-19740
- ELECTROMAGNETIC FIELD AND SECOND OPTICAL HARMONIC GENERATED IN LASER RESONATOR AS TWO INTERDEPENDENT PROCESSES A65-25271
- KINETIC EQUATION THEORY APPLIED TO STEADY STATE LASER RADIATION DUE TO BAND-BAND TRANSITION IN SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS A65-26694
- QUASI- FERMI LEVEL, FREQUENCY, THRESHOLD PUMPING VALUE AND PARTICULAR MODE IN RADIATIVE INTRABAND TRANSITION A65-31884
- KINETIC EQUATION THEORY APPLIED TO STEADY STATE LASER RADIATION DUE TO BAND-BAND TRANSITION IN SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS A65-32952
- LASER EMISSION WITH VARIABLE RESONATOR LOSSES, CONSIDERING RELATIVELY LOW INITIAL OVERPOPULATION A65-35784
- KINETIC EQUATION OF LASER OPTIMUM EMISSION, DETERMINING PUMPING EFFICIENCY, VALUE OF LOSSES IN SPECIAL MODES, ETC A66-11058
- SEMICONDUCTOR LASER RADIATION BY DIRECT ZONE-TO-ZONE TRANSITIONS A66-14273
- QUASI- FERMI LEVEL, FREQUENCY, THRESHOLD PUMPING VALUE AND PARTICULAR MODE IN RADIATIVE INTRABAND TRANSITION A66-18361
- SECOND HARMONIC GENERATION BY LASER BEAMS OF FINITE SPECTRAL WIDTH, USING QUANTUM TRANSITIONS AND KINETIC EQUATIONS, NOTING SHAPE OF PUMPING LINE AT FUNDAMENTAL FREQUENCY A66-22026
- WIDTH OF LINES EMITTED BY LASER MODELS FTD-TT-64-841 N65-14217
- LASER IRRADIATION ON SECOND OPTICAL HARMONICS FTD-TT-65-25/1 N65-29889
- MASHTAKOV, V. S.  
FORCED EMISSION FROM ELECTRON-EXCITED CADMIUM SELENIDE A66-22174
- MASSEY, G. A.  
GENERATION OF SINGLE FREQUENCY LIGHT USING FM LASER A65-16670
- SENSITIVITY OF COHERENT OPTICAL HETERODYNE RECEIVER IN DETECTING LASER RADIATION REFLECTED FROM DIFFUSE SURFACE A65-28005
- SUPERMODE LASER AS SINGLE-FREQUENCY GENERATION SYSTEM CONSISTING OF FM LASER WITH SYNCHRONOUS PHASE MODULATOR AT OUTPUT A65-29267
- CONTROLLING FM AND SUPERMODE LASER OUTPUT FREQUENCIES BY THRESHOLD CONTROL AND INTERFEROMETRIC CONTROL A65-36842
- OPTICAL HETERODYNE DETECTION OF MICROWAVE MODULATED LIGHT USING TWO SEPARATE LASERS EDL-M779 N65-16777
- MASTERS, J. I.  
ACTIVE AND PASSIVE Q-SWITCHES FOR INCREASING STORED PUMPING ENERGY OF LASERS AND INHIBITING RESONANCE FOR SUBSEQUENT PEAK LASER EXCITATION AND DISCHARGE A65-35118
- RUBY LASER Q-SWITCHING USING PASSIVE SOLID STATE OR LIQUID ORGANIC BLUE DYE TO-B-64-15 N65-22933
- MASTRUP, F. M.  
FAST HIGH RADIANCE ABLATING LASER PUMP AND ENERGY STORAGE TECHNIQUE AFAL-TR-65-22 N65-22702
- MASUDA, Y.  
UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE RUBY LASER TECHNIQUES, PRESENTING HEIGHT DISTRIBUTION CURVES OF SCATTERED LIGHT A66-13376
- MATARE, H. F.  
PARAMETER DEPENDENCE OF INTERMEDIATE FREQUENCY VOLTAGE INDICATED DURING ESTABLISHMENT OF OPTIMUM CONDITIONS FOR OPTICAL RECEIVERS AND MERIT OF SUBCARRIER MIXING A66-23960
- MATHIAS, L. E. S.  
GAS LASER CONTINUOUS WAVE AMPLIFIER USING RECTANGULAR CROSS SECTION DISCHARGE TUBE, NOTING OPERATION AS CW OSCILLATOR AND PULSE AMPLIFIER A65-16406
- LASER OSCILLATIONS FROM PULSED ELECTRICAL DISCHARGE THROUGH NITROUS OXIDE AT 10.9 MICRON WAVELENGTH N65-20172
- LASER OSCILLATIONS AT WAVELENGTHS BETWEEN 21 AND 32 MICRONS FROM PULSED DISCHARGE THROUGH AMMONIA N65-20173
- MATHUR, B.  
DIRECT FREQUENCY COMPARISON OF ATOMIC HYDROGEN MASERS IN DIFFERENT PLACES AND CONDITIONS BY SIMULTANEOUS MONITORING OF LORAN C SIGNALS A66-24145
- MATLACK, D. E.  
GREEN LASER LIGHT TRANSMISSION THROUGH WATER NOLTR-64-179 N65-20605
- MATSUHARA, M.  
ELECTRIC CIRCUIT ANALOG OPTIMUM DESIGN OF MODE-SELECTIVE MULTIREFLECTOR FABRY-PEROT LASER RESONATORS A65-30344
- MULTIREFLECTOR FABRY-PEROT LASER RESONATORS, DISCUSSING SUPPRESSION EFFECT AGAINST UNWANTED MODES A66-13325

- MODULATION OF LASER LIGHT WITH COMPOSITE FABRY-PEROT RESONATOR, USING MORE THAN THREE MULTIPLE REFLECTING PLATES A66-15836
- MATSUZAMA, H.**  
OPTICAL DESIGN OF ELLIPTICAL CAVITIES AND COMPARISON OF ENERGY TRANSFERS FROM LIGHT SOURCE TO RUBY LASER WITH CYLINDRICAL CAVITIES A66-16647
- MATVEENKO, L. I.**  
TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN 8-CM BAND A65-24882  
TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN 8-CM BAND A65-36359
- MAUER, P.**  
NEODYMIUM DOPED LASER GLASS COMPARED ON BASIS OF FLOURESCENCE CHARACTERISTIC DIFFERENCES AD-612459 N65-25901
- MAURER, R. D.**  
GLASS COMPOSITION EFFECT ON SPECTRAL PROPERTIES OF ND-DOPED GLASSES AND SELECTING ONE FOR LASER GLASS A65-17635  
SPECTRAL PUMPING EFFICIENCY, SOLARIZATION EFFECT, ENERGY OUTPUT, SPECTROSCOPY, GLASS DAMAGE AND OPTICAL PATH DISTORTIONS IN NEODYMIUM GLASS LASERS AD-612964 N65-24195  
EFFECTS OF INTENSE ULTRAVIOLET RADIATION ON GLASS MATERIALS, AND PERFORMANCE CHARACTERISTICS OF GLASS LASERS AD-623309 N66-14533
- MAX, E.**  
USE OF OPTICAL MASERS IN DISPLAYS AND PRINTERS - DIGITAL ELECTRO-OPTIC LIGHT DEFLECTOR, CEMENTING OF CALCITE CRYSTALS, HIGH SPEED ELECTRONIC SWITCHES, AND BIREFRINGENT CRYSTALS REPT.-6 N65-13857
- MAY, E.**  
PERIODIC VARIATION OF QUALITY FACTOR OF HE- NE GAS LASER CAVITY BY VIBRATING QUARTZ-MODULATION OF LIGHT BEAM A66-13477
- MAYER, G.**  
MOLECULAR ANISOTROPY OF PROPAGATION OF INTENSE LIGHT BEAM, NOTING RAMAN AND BRILLOUIN EFFECTS A66-15106
- MAZURENKO, IU. T.**  
SOME LASER PROPERTIES FROM VIEWPOINT OF SECOND LAW OF THERMODYNAMICS OF IRREVERSIBLE PROCESSES A65-31376  
SOME LASER PROPERTIES FROM VIEWPOINT OF SECOND LAW OF THERMODYNAMICS OF IRREVERSIBLE PROCESSES A66-14899
- MAZUROV, IU. A.**  
RESONATOR MADE OF MAGNETIC MATERIALS FOR TUNING MOLECULAR GENERATOR BY ZEEMAN MODULATION A66-20792
- MC BRAYER, R. D.**  
LASER CRYSTAL GROWTH, CHARACTERIZATION, AND SURFACE FINISHING N65-17597
- MC CAULEY, D. G.**  
OPTICAL CHARACTERISTICS OF PROTOTYPE LASER MODULATORS WITH THIN, FLAT, DISK-SHAPED FABRY-PEROT INTERFEROMETER DESIGN - LASER RADIATION IN COMMUNICATIONS N65-31681  
LIGHT EMISSION FROM GALLIUM ARSENIDE SEMICONDUCTOR P-N JUNCTION INJECTION LASER N66-19703
- MC GUNIGAL, T. E.**  
COMPARISON OF HYDROGEN MASER AND OF CESIUM BEAM TUBE FREQUENCY STANDARD
- NASA-TN-D-3292 N66-21698
- MC MORRIS, D. W.**  
RADIATION SCATTERING FROM LASER BEAM BY FREE PLASMA ELECTRONS NSL-64-168-1 N65-20300
- MC MURTRY, B. J.**  
PROPERTIES OF FREQUENCY MODULATION AND SUPER MODE LASER IER-1 N66-10766  
EXPERIMENTAL AND THEORETICAL PROGRAM TO DETERMINE FUNDAMENTAL PROPERTIES OF FREQUENCY MODULATION AND SUPER-MODE LASERS IER-2 N66-21405
- MC WANE, P. D.**  
OUTPUT AND DIVERGENCE MEASUREMENTS FOR Q-SWITCHED KERR CELL LASER REPT.-1579-18 N65-16819
- MC WHORTER, A. L.**  
SOLID STATE DEVICE, LASER, MATERIALS, BAND STRUCTURE AND SPECTROSCOPY OF SOLIDS, AND MAGNETISM AND RESONANCE RESEARCH ESD-TDR-64-560 N65-16944  
SOLID STATE PHYSICS - LASERS, SPECTROSCOPY OF SOLIDS, MAGNETISM, AND RESONANCE ESD-TDR-64-561 N65-19317  
LASER, MATERIALS, AND SOLID STATE RESEARCH, BAND STRUCTURE AND SOLIDS SPECTROGRAPHY, AND MAGNETISM AND RESONANCE ESD-TDR-64-349 N65-19816
- MCAVOY, M.**  
JUSTIFICATION GIVEN FOR USING 10 MICRON WAVELENGTH IN DEEP SPACE LASER COMMUNICATION SYSTEM NASA-TM-X-55396 N66-17234
- MCCALL, G.**  
OPTICAL PUMP PULSE SHAPE EFFECT ON POPULATION INVERSION ATTAINED IN RUBY LASER A65-16569
- MCCARTNEY, A. J.**  
BIOLOGICAL EFFECTS OF LASER RADIATION WITH REFERENCE TO INTACT ANIMALS, PRIMATE EYES AND SKIN AND MALIGNANT TUMORS OF ANIMAL AND HUMAN ORIGIN A66-12994
- MCCLUNG, F. J.**  
GIANT PULSE LASER APPLIED TO NONLINEAR OPTICAL EFFECT OF STIMULATED RAMAN SCATTERING WITH REFERENCE TO EMISSION ANGLE MEASUREMENT TECHNIQUE A65-19996  
LONGITUDINAL MODE SELECTION IN GIANT PULSE LASER RESULTING IN SINGLE-MODE OUTPUT A65-30345  
OBSERVED AND PREDICTED EFFICIENCY OF CONVERSION OF RADIATION FROM GIANT PULSE RUBY LASER INTO STIMULATED RAMAN SCATTERING A65-32209  
MODE-CONTROLLED GIANT PULSE LASER USED TO PRODUCE TWO-BEAM HOLOGRAM IN SHORT EXPOSURE TIME OF 30 NSEC A66-12215
- MCCLURE, R. E.**  
SELF-LOCKED GAS LASER MODE DEPENDENCE ON CAVITY LENGTH AND POSITION OF LASER MEDIUM IN CAVITY A66-10347
- MCCORMICK, P. D.**  
RUBY LASER OPTICAL RADAR DETECTION OF UPPER ATMOSPHERIC BACKSCATTERING A66-24395
- MCCUBBIN, T. K., JR.**  
HELIUM-NEON LASER AMPLIFIER AS FUNCTION OF MIXTURE RATIO, GAS PRESSURE, INPUT SIGNAL LEVEL AND ELECTRICAL POWER INPUT TO AMPLIFIER TUBE A66-12206
- MCCUMBER, D. E.**  
DIFFRACTION LOSSES AND FIELD DISTRIBUTIONS AT REFLECTORS OF LOW-LOSS MODES OF SYMMETRIC CONFOCAL

- LASER RESONATOR A65-18315
- INTENSITY FLUCTUATIONS IN OUTPUT OF FOUR-LEVEL CW LASER OSCILLATORS BY LINEARIZED RATE EQUATIONS A66-18434
- MC DUFF, O. P.  
LASER OSCILLATION WHEREIN LASER MODES OSCILLATE WITH APPROXIMATELY FM PHASES THEREBY COMPRISING SIDEBANDS OF FM LIGHT SIGNAL A65-21876
- F M LASER OSCILLATION THEORY DISCUSSING EFFECT OF ARBITRARY ATOMIC LINE SHAPE, SATURATION, MODE PULLING, POWER OUTPUT, SIDEBAND AMPLITUDE, DISTORTION, ETC A66-13954
- MC EVOY, J. P., JR.  
TRAVELING WAVE MASER EMPLOYING MAGNETIC STAGGER TUNING IN SMALL COMPACT SUPERCONDUCTING MAGNET ACHIEVES TRADING EXCESS ELECTRONIC GAIN FOR BANDWIDTH A65-29196
- TRAVELING WAVE MASER SUPERCONDUCTING MAGNET COOLED IN CLOSED-CYCLE REFRIGERATOR BY THERMAL CONDUCTION A65-32128
- MC FEE, J. H.  
C W HIGH-POWER CARBON DIOXIDE-NITROGEN-HELIUM LASER OPERATION, NOTING HELIUM ADDITION A66-16754
- MC GOWAN, J. W.  
CHARGE TRANSFER AS LASER PUMPING TECHNIQUE A65-20063
- MC MAHON, D. H.  
SECOND HARMONIC GENERATION AND MEASUREMENT OF NONLINEAR POLARIZATION CONSTANT IN ADP, USING FOCUSED LASER BEAM A65-16672
- MC MULLIN, P. G.  
MICROWAVE AMPLIFICATION ACHIEVED IN SILICON DIODE EXHIBITING MICROPLASMA-FREE AVALANCHE MULTIPLICATION A65-19227
- MC MURTRY, B. J.  
CARRIER FREQUENCY STABILIZATION OF FM LASER WITH RESPECT TO CENTER OF ATOMIC GAIN PROFILE, USING SMALL DISTORTION PRESENT IN LASER OSCILLATION A66-10966
- EXPERIMENTS ON HELIUM-NEON FM LASERS COVERING PHASE-LOCKED AND FM REGION POWER OUTPUT, MODULATION INDEX AND DISTORTION EXPERIMENTS A66-13955
- FREQUENCY-SELECTIVE TRANSMISSION ETALON REPLACES END MIRROR OF FM LASER SO THAT TOTAL POWER IS OBTAINED AS SINGLE OPTICAL FREQUENCY A66-16381
- MEADORS, J. G.  
OPTICAL COHERENCE AND NONLINEAR INTERACTION OF LIGHT WAVES IN DIELECTRICS REPT.-1579-17 N65-21553
- MENTA, C. L.  
RELATION BETWEEN QUANTUM AND SEMICLASSICAL DESCRIPTION OF OPTICAL COHERENCE, CONSIDERING DISTRIBUTION FUNCTION A65-21379
- MELAMED, M. T.  
LASER OSCILLATION INCREASE IN EFFICIENCY IN NEODYMIUM DOPED GLASS PRODUCED THROUGH ENERGY TRANSFER A66-10352
- MELNGAILIS, I.  
IN SB LONGITUDINAL INJECTION-PLASMA LASER, NOTING PLASMA PINCH AND MODE STRUCTURE A65-17210
- INDIUM ARSENIDE DIODE SPONTANEOUS AND LASER ELECTROLUMINESCENCE IN MAGNETIC FIELDS A65-24961
- MENAT, M.  
OPTIMUM PEAK POWER FROM GIANT PULSE LASER IN TERMS OF LOSS FACTOR AND POPULATION DENSITY A65-15824
- MENEELY, C. T.  
SODIUM-MERCURY METAL VAPOR LASER SP/PH/65-15 N65-33995
- MENIUS, A. C., JR.  
CO-60 GAMMA IRRADIATION INDUCED ENERGY OUTPUT INCREASE OF RUBY LASER CRYSTAL A65-17687
- ENERGY OUTPUT INCREASE OF RUBY LASER CRYSTAL SYSTEMS BY NUCLEAR ENERGY, LASER CRYSTAL GROWTH, AND SURFACE FINISH DEVELOPMENT AD-455571 N65-17595
- MENNE, T. J.  
SPATIALLY INDEPENDENT LASER RATE EQUATION GENERALIZED FOR MULTIMODE EFFECTS, NULLING STEADY STATE OSCILLATION THRESHOLD SINGULARITIES, SPIKING PARAMETERS, ETC A66-24560
- STEADY STATE VALUE OF INVERTED POPULATION, POWER OUTPUT, THRESHOLD BEHAVIOR AND SPIKING CHARACTERISTICS FOR SINGLE-MODE LASER WHEN RADIATION INTENSITY HAS SPATIAL DEPENDENCE A66-24562
- MENTALL, J. E.  
SPECTROSCOPIC INVESTIGATION OF LASER EXCITED MOLECULAR SPECTRA FROM POWDERED SOLIDS FOR METEOR AND REENTRY PHYSICS A65-16302
- MERCER, G. N.  
MEASUREMENT OF GAS LASER RADIATIVE DECAY RATES AND TOTAL INELASTIC DESTRUCTIVE CROSS SECTION OF SHORT LIVED EXCITED STATES IN 4-NSEC TO 1000-NSEC RANGE A65-20061
- MERI, H.  
MODULATION OF LASER LIGHT WITH COMPOSITE FABRY-PEROT RESONATOR, USING MORE THAN THREE MULTIPLE REFLECTING PLATES A66-15836
- MESHCHERIAKOV, A. V.  
OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF SOLID STATE LASER AND COMPENSATION VIA LENS IN RESONATOR A65-36051
- OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF SOLID STATE LASER AND COMPENSATION VIA LENS IN RESONATOR A66-15854
- MET, V.  
HELIUM-NEON GAS LASERS, DISCUSSING AMPLITUDE VARIATION SUPPRESSION TECHNIQUE A66-16670
- MEULEMAN, J.  
PHYSICAL CONDITIONS FOR OBTAINING LASER EFFECT IN P-N JUNCTION AND TECHNOLOGY IN CONSTRUCTING LASER DEVICES A65-23847
- MEYER, C.  
LINEAR COEFFICIENT OF AMPLIFICATION OF CARBON DIOXIDE SUBJECTED TO HF EXCITATION FIELD FOR LASER EMISSION A66-12003
- MEYER, Y. H.  
PERIPHERAL MODES IN CHELATE LASER, NOTING LUMINESCENCE EMITTED BY AXIS OF CYLINDRICAL CELL AND LATERAL FACE A66-15171
- MEYERAND, R. G., JR.  
PLASMA PRODUCTION BY OPTICAL IRRADIATION OF GASES AND BY SOLIDS, CONSIDERING INTERACTION OF LASER RADIATION WITH SURFACES AND IRRADIATION OF PARTICLES OF SOLID MATERIAL IN VACUUM AIAA PAPER 66-174 A66-22212
- MICHEL, A. E.  
CURRENT DISTRIBUTION CONTROL IN GALLIUM ARSENIDE INJECTION LASER SHOWING EFFECTS ON OSCILLATION MODE AND THRESHOLD A65-17665
- GA AS OPTICALLY COUPLED TRANSISTOR STRUCTURE WITH LASING EMITTER A66-12442
- MIDWINTER, J. E.  
C-SWITCHING APPLIED TO SLOW SWITCHING AND PULSE SHAPING FOR SOLID STATE LASERS AIAA PAPER 65-343 A65-30797

**MIELENZ, K. D.**

GAS MIXTURES AND PRESSURES FOR OPTIMUM OUTPUT  
POWER OF RF-EXCITED HELIUM-NEON GAS LASERS AT  
632.8 NM A65-22620

WAVELENGTH OF 3S2-2P4 TRANSITION OF NEON MEASURED,  
USING HELIUM-NEON LASER A66-16387

ABSOLUTE WAVELENGTH STABILITY OF HELIUM-NEON LASER  
MEASURED BY DIRECT INTERFEROMETRIC COMPARISON WITH  
HG 198 STANDARD LAMP A66-22868

**MIERZECKI, R.**

CURRENT STATUS OF THEORETICAL AND EXPERIMENTAL  
STUDIES OF VARIANT OF RAMAN EFFECT ENCOUNTERED IN  
SCATTERING OF LASER LIGHT A66-12065

**MIKAELIAN, A. L.**

CONTINUOUS REGIME OPTICAL GENERATOR OUTPUT,  
THRESHOLD PUMPING LEVEL, INVERSE POPULATION  
DENSITY AND INDUCED RADIATION ENERGY A65-20326

RUBY LASER THRESHOLD PUMPING AND EMISSION ENERGIES  
RELATED TO TRANSMISSION COEFFICIENT, ROD DIAMETER  
AND THRESHOLD LEVEL A65-20343

INTERNAL LOSSES EFFECT ON RADIATION POWER IN LASER  
A65-24058

LASER WITH DIFFRACTION LIMITED RADIATION PATTERN  
A66-10450

LASER WITH DIFFRACTION LIMITED RADIATION PATTERN  
A66-13313

PARASITIC INTERNAL OSCILLATIONS IN LASER CRYSTAL  
WITH DIELECTRIC ROD CAUSED BY TOTAL REFLECTION  
FROM GENERATRIX OF CYLINDRICAL SAMPLE A66-22739

**MIKHAILOV, G. V.**

GAS LASER OUTPUT AND THRESHOLD IN POPULATION  
INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE  
AND FLUORO IODO METHYLIDYNE A66-16771

**MIKHNOV, S. A.**

RUBY LASER NOISE RADIATION CONSISTING OF INCREASED  
LUMINESCENCE AND Laterally DISPERSED GENERATION  
DETERMINED FROM ENERGY LEVEL POPULATIONS A65-35863

RADIATION SCATTERING FACTOR DETERMINATION FOR RUBY  
LASER A65-36013

RUBY LASER NOISE RADIATION CONSISTING OF INCREASED  
LUMINESCENCE AND Laterally DISPERSED GENERATION  
DETERMINED FROM ENERGY LEVEL POPULATIONS A66-16628

**MILLER, B.**

MAGNETIC FIELD PROBE IN ELECTROMAGNETICALLY DRIVEN  
SHOCK TUBE AND COHERENT LIGHT IN IONIZING SHOCK  
WAVE PLASMA DIAGNOSTICS A65-29569

**MILLER, D. J.**

TRAVELING WAVE MASER EMPLOYING MAGNETIC STAGGER  
TUNING IN SMALL COMPACT SUPERCONDUCTING MAGNET  
ACHIEVES TRADING EXCESS ELECTRONIC GAIN FOR  
BANDWIDTH A65-29196

C-BAND TRAVELING WAVE MASER / TWM/ WITH IRON DOPED  
RUTILE CRYSTAL AND MEANDER LINE SLOW WAVE CIRCUIT  
A65-33373

**MILLER, K. J.**

LASER WELDING TECHNIQUE EXAMINING JOINT DESIGN,  
WELDABLE MATERIALS AND COSTS A65-32798

PRODUCTION LASER WELDING OF INTRICATE AND CRITICAL  
SUBASSEMBLIES INCORPORATED INTO SPACE VEHICLES AND  
COMPONENTS A66-14514

**MILLER, R. C.**

VELOCITY MATCHED SECOND HARMONIC GENERATION / SHG/  
AND MIXING OBTAINED IN PIEZOELECTRIC LITHIUM  
NIOBATE CRYSTALS A65-19235

CONSTRUCTION PROBLEMS OF CONTINUOUS-DUTY DC

## EXCITED ION LASERS

A66-13956

**MILLER, S. E.**

OSCILLATION, MODULATION AND TRANSMISSION PROBLEMS  
REGARDING LONG DISTANCE ELECTRIC SIGNAL  
COMMUNICATION POSSIBILITIES OF LASERS A66-18359

**MILLWARD, G. F. D.**

GC/S NITROGEN-COOLED NONDEGENERATE PARAMETRIC  
AMPLIFIER, NOTING DESIGN, APPLICATION AND  
OPERATION CHARACTERISTICS A66-21857

**MILOVSKII, N. D.**

PLANE STATIONARY MODE OF TW LASER AMPLIFIER WITH  
FEEDBACK A65-19683

**MINCK, R. W.**

LASER INDUCED GAS BREAKDOWN AT HIGH PRESSURES,  
NOTING EFFECT OF PLASMA DENSITY ON INDEX OF  
REFRACTION VIA OPTICAL FREQUENCY RESONANCE  
MEASUREMENT A66-21564

**MINDEN, H. T.**

FORWARD BIASED P-N JUNCTION ELECTROLUMINESCENCE  
THEORY AND APPLICATIONS TO DIODE LASERS A65-18872

LIGHT EMISSION IN FORWARD BIASED SEMICONDUCTOR  
P-N JUNCTION A66-12577

EPITAXIAL DEPOSITION OF GERMANIUM ON GALLIUM  
ARSENIDE BY HYDROGEN REDUCTION OF GERMANIUM  
TETRACHLORIDE - SEMICONDUCTOR AND LASER  
PRODUCTION  
SRRC-RR-65-52 N65-34688

**MISEZHNIKOV, G. S.**

QUANTUM ACTIVE PARAMAGNETIC AMPLIFIER IN FORM OF  
SERIES-COUPLED RESONATORS, NOTING BANDWIDTH  
DEPENDENCE ON RESONATOR NUMBER AND DECOUPLING  
INDEPENDENCE A65-14137

QUANTUM ACTIVE PARAMAGNETIC AMPLIFIER IN FORM OF  
SERIES-COUPLED RESONATORS, NOTING BANDWIDTH  
DEPENDENCE ON RESONATOR NUMBER AND DECOUPLING  
INDEPENDENCE A65-24012

TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
8-CM BAND A65-24882

TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
8-CM BAND A65-36359

**MITCHELL, R. C.**

REFRACTIVE INDEX VARIATION DURING LASER OPERATION  
AND CAST-PLASTIC OPTICAL-PUMP CAVITY EQUIPMENT  
FOR PUMPING AND TEMPERATURE CONTROL DURING  
EXPERIMENT  
SATR-1 N65-15753

EFFECT OF OPTICAL PUMPING ON ANOMALOUS DISPERSION  
IN SELECTED RUBY LASERS AND VARIATION OF  
REFRACTIVE INDEX DURING LASER OPERATION  
SATR-3 N65-28619

**MITCHELL, R. R.**

RAYLEIGH SCATTERING USING LASER LIGHT FOR  
DETERMINATION OF SCATTERING DENSITY OF ARGON,  
OXYGEN, AND NITROGEN  
R-135 N65-26127

**MIYSAI, V. N.**

HELIUM-NEON LASER OUTPUT CHARACTERISTICS AS  
FUNCTION OF LASER PARAMETERS A65-31375

HELIUM-NEON LASER OUTPUT CHARACTERISTICS AS  
FUNCTION OF LASER PARAMETERS A66-14897

**MOCKER, H. W.**

MODE COMPETITION AND COUPLING IN Q-SWITCHED RUBY  
LASER A66-16383

**MOECKEL, P.**

CONICAL EMISSION IN RUBY LASERS WITH EXTERIOR  
PIRROCS A66-14278

- MOELLER, G.**  
C W LASER ACTION IN CARBON DIOXIDE-HELIUM MIXTURES  
A66-16385
- LASER ACTION ON ROTATIONAL LINE IN CARBON DIOXIDE  
AND NITROUS OXIDE VIBRATIONAL SPECTRA IN BOTH P  
AND R BRANCHES UP TO J VALUES OF OVER 50  
A66-23357
- MOELLER, G. K.**  
HELIUM-NEON LASER AMPLIFIER AS FUNCTION OF MIXTURE  
RATIO, GAS PRESSURE, INPUT SIGNAL LEVEL AND  
ELECTRICAL POWER INPUT TO AMPLIFIER TUBE  
A66-12206
- MOFFAT, J. W.**  
PROPOSED EXPERIMENT TO OBSERVE STIMULATED PHOTON -  
PHOTON SCATTERING WITH LASER POWER  
N65-31459
- MOFFATT, J. P.**  
OPTIMIZING FLASH LAMPS FOR PUMPING LASER RODS  
BY MEANS OF DOPING  
AD-613346 N65-25890
- MOLLET, P.**  
NEW OPTICS TECHNIQUES INCLUDING INTERFERENCE  
FILTERS, LASERS AND OPTICAL FIBERS  
A66-19118
- MOLZ, F.**  
LASER EXCITATION IN QUARTZ OF ELASTIC MODES OF  
THICK PLATE, SUGGESTING ENERGY COUPLING MECHANISMS  
A66-12423
- MONROE, H. E.**  
SIGNAL AND NOISE OUTPUT OF OPTICAL LASER SYSTEMS  
REPT.-1935-7 N66-15966
- MOORE, C. B.**  
GAS LASER MOLECULAR ABSORPTION DISCRIMINATION OF  
CLOSE FREQUENCIES  
A65-15998
- MOORE, J. S.**  
ZINC DIFFUSION IN GALLIUM ARSENIDE-PHOSPHIDE  
LASERS AND EFFECTS ON SEMICONDUCTOR JUNCTIONS  
AFCL-66-18 N66-22611
- MOORE, R. S.**  
BUILDUP AND DECAY TRANSIENT EFFECTS IN GAS LASERS  
DUE TO LIGHT ABSORPTION BY INSERTED LIQUID SAMPLES  
A65-15816
- MOREHEAD, F. F.**  
SWITCHING CHARACTERISTICS OF NEGATIVE RESISTANCE  
DIODE DETERMINATION - INJECTION LASER  
REPT.-7 N65-27203
- MORGAN, H. W.**  
INEXPENSIVE SIMPLIFIED CONSTRUCTION OF DC POWERED  
HELIUM NEON LASER WITH 6328 ANGSTROM OUTPUT  
A65-19849
- MORGENTHAU, Z. L.**  
EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING  
SPECTRAL RANGE, DURATION, ELECTRON EXCITATION  
MECHANISM AND UPPER WAVELENGTH LIMIT  
A66-19667
- EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING  
SPECTRAL RANGE, DURATION, ELECTRON EXCITATION  
MECHANISM AND UPPER WAVELENGTH LIMIT  
A66-21834
- MORI, H.**  
ELECTRIC CIRCUIT ANALOG OPTIMUM DESIGN OF MODE-  
SELECTIVE MULTIREFLECTOR FABRY- PEROT LASER  
RESONATORS  
A65-30344
- MULTIREFLECTOR FABRY- PEROT LASER RESONATORS,  
DISCUSSING SUPPRESSION EFFECT AGAINST UNWANTED  
MODES  
A66-13325
- MOROZOV, V. N.**  
TIME DEPENDENCE OF LASER OPERATION MODES USING  
LASER MODEL WITH TWO OSCILLATION TYPES  
A65-27772
- NONLINEAR INTERACTION OF OSCILLATIONS OF TWO TYPES  
IN LASER DOES NOT AFFECT STATIONARY OPERATION WHEN  
OSCILLATIONS ARE SUFFICIENTLY APART IN BAND  
A66-10724
- TIME DEPENDENCE OF LASER OPERATION MODES, USING  
LASER MODEL WITH TWO OSCILLATION TYPES  
A66-16626
- MORRIS, L. C.**  
TRAVELING WAVE MASER EMPLOYING MAGNETIC STAGGER  
TUNING IN SMALL COMPACT SUPERCONDUCTING MAGNET  
ACHIEVES TRADING EXCESS ELECTRONIC GAIN FOR  
BANDWIDTH  
A65-29196
- TRAVELING WAVE MASER SUPERCONDUCTING MAGNET  
COOLED IN CLOSED-CYCLE REFRIGERATOR BY THERMAL  
CONDUCTION  
A65-32128
- C-BAND TRAVELING WAVE MASER / TWM/ WITH IRON DOPED  
RUTILE CRYSTAL AND MEANDER LINE SLOW WAVE CIRCUIT  
A65-33373
- MORRIS, R. J.**  
INTERNAL TUNING METHODS FOR CONTINUOUS WAVE  
LASERS OVER ANGSTROM BANDWIDTHS  
SEL-64-092 N65-14369
- MORRISON, B. H.**  
RUBY LASER PULSE TECHNIQUE APPLIED TO THERMAL  
DIFFUSIVITY MEASUREMENTS FOR TANTALUM AND  
GRAPHITE  
CONF-651020-1 N66-18228
- MORSE, J. H.**  
CONTINUOUSLY PULSED LASER DEVICE WITH SELF-  
CONTAINED LASER OSCILLATOR AND POWER SUPPLY -  
LASER HEADS USING TUNGSTEN LAMPS AND XENON  
FLASHLAMPS FOR PUMP EXCITATION  
REPT.-2 N65-27581
- MOSS, E. B.**  
IMPROVEMENTS NEEDED IN LASER TECHNOLOGY BEFORE  
OPTICAL COMMUNICATION CAN REPLACE UHF BECAUSE OF  
LIMITED RELIABILITY OF MICROBEAM OPTICAL LINK  
A65-23196
- ACQUISITION AND REACQUISITION IN SPACECRAFT-  
SPACECRAFT AND SPACECRAFT-TO- EARTH COMMUNICATIONS  
USING LASER SYSTEMS  
A65-28249
- ACQUISITION, TRACKING AND BEAM POINTING FOR  
OPTICAL COMMUNICATION IN SPACE  
AIAA PAPER 64-420 A65-33536
- MOSS, M. K.**  
CO-60 GAMMA IRRADIATION INDUCED ENERGY OUTPUT  
INCREASE OF RUBY LASER CRYSTAL  
A65-17687
- GAMMA RADIATION EFFECT ON ENERGY OUTPUT OF RUBY  
LASER CRYSTALS  
N65-17596
- MOVCHAN, B. A.**  
RUBY AND NEODYMIUM GLASS LASERS FOR INDUSTRY -  
ELECTRONICS  
N65-23722
- MOVSESIAN, M. E.**  
R SUB 1 RUBY LINE EMISSION AND FREQUENCY  
DEPENDENCE ON TEMPERATURE VARIATION  
A65-15205
- MOVE, J.**  
REFLECTED RADIATION OF Q-SPOILED RUBY LASER FROM  
EXPLORER XXII  
A65-21306
- MUELLER, H. A.**  
RECORDING SAMPLING SYSTEM FOR MEASURING ENERGY  
INCIDENT ON BIOLOGICAL SYSTEM EXPOSED TO LASER  
BEAM  
A66-17293
- MUELLER, L.**  
CROSS CORRELATION MEASUREMENTS OF OSCILLATOR  
FREQUENCY STABILITY AND THERMAL NOISE AND  
APPLICATION TO ATOMIC HYDROGEN MASER  
A66-24128
- DIRECT FREQUENCY COMPARISON OF ATOMIC HYDROGEN  
MASERS IN DIFFERENT PLACES AND CONDITIONS BY  
SIMULTANEOUS MONITORING OF LORAN C SIGNALS  
A66-24145

A65-34663

MUKHINA, M. N.

TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
8-CM BAND A65-24882

TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
8-CM BAND A65-36359

MULLER, M. W.

FEASIBILITY OF LASER OPERATING ON VIBRATIONAL -  
TRANSITIONS - SCHEMES USING FRANCK-CONDON  
PRINCIPLE  
VARIAN-314-35 N65-28168

MURANAGA, K.

UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE  
RUBY LASER TECHNIQUES, PRESENTING HEIGHT  
DISTRIBUTION CURVES OF SCATTERED LIGHT A66-13376

MURINA, T. M.

LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING  
FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM  
ION IN VARIOUS CONCENTRATIONS A65-24881

LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING  
FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM  
ION IN VARIOUS CONCENTRATIONS A65-36358

LASER REGIME WITH GIANT PULSES GENERATED IN  
DYSPROSIUM DOPED CADMIUM FLUORIDE UNDER CONTINUOUS  
PUMPING BY XENON LAMPS, OBTAINING Q FACTOR  
MODULATION BY ROTATING PRISM A66-19376

MURRAY, E. M. E.

RUBY LASER Q-SWITCHING USING PASSIVE SOLID STATE  
OR LIQUID ORGANIC BLUE DYE  
TO-B-64-15 N65-22933

MURRAY, G. T.

ELECTRON BEAM AND HOLLOW CATHODE FLOAT-ZONE  
PROCESSES ANALYSIS FOR APPLICATION TO GROWTH OF  
LASER RUBY CRYSTALS  
AFCL-65-908 N66-21169

MYERS, R. A.

ELECTRICAL SWITCHING OF EMISSION DIRECTION OF  
LASER OSCILLATOR BY INTERNAL DEFLECTION OF LASER  
BEAM A65-16403

LASER DEFLECTION AND SCANNING BY MEANS OF  
MULTIMODE CAVITIES WITH DYNAMIC SPATIAL FILTERS  
A66-14829

## N

NANDIKIN, YU. V.

LASER MIRRORS CONSISTING OF ALTERNATING LEAD-OXIDE  
AND CRYOLITE FILMS A65-26039

LASER MIRRORS CONSISTING OF ALTERNATING LEAD-OXIDE  
AND CRYOLITE FILMS A66-11820

NAGATAKE, T.

UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE  
RUBY LASER TECHNIQUES, PRESENTING HEIGHT  
DISTRIBUTION CURVES OF SCATTERED LIGHT A66-13376

NAINAN, C. S.

EFFECT OF LASER RADIATION ON CHEMICAL ACTIVATION  
AND VAPOR FOG NUCLEATION  
MC-64-110-R1 N65-27760

NAKASUJI, M.

MODE DEGENERACY-DIPS ON OUTPUT OF HE-NE LASER  
FOR CERTAIN CRITICAL COMBINATION OF MIRROR  
CURVATURES AND SEPARATION A65-36703

NANBA, S.

GIANT RUBY LASER PULSE PRODUCTION FROM RAPID  
SATURATION OF DYE ABSORBER SOLUTION IN OPTICAL  
CAVITY BY SINGLET-SINGLET TRANSITIONS  
A65-33521

NANNICHI, Y.

THRESHOLD INTENSITY OF 8400 ANGSTROM LIGHT FROM  
GALLIUM ARSENIDE LASER DIODE AND EYE DAMAGE

NASSAU, K.

CHEMICAL AND PHYSICAL ASPECTS OF LASERS AND LASER  
MATERIALS WITH REGARD TO TESTING AND SPECIFICATION  
REQUIREMENTS A65-14621

RARE EARTHS IN OPTICAL MASER MATERIALS, DISCUSSING  
CHEMICAL INTERACTIONS BETWEEN ACTIVE ION AND HOST  
LATTICE A65-17052

CONTINUOUS OPTICAL SECOND-HARMONIC GENERATION  
USING Nd:YAG LASER AND CRYSTAL OF SINGLE-DOMAIN  
LITHIUM NIOBATE A66-16378

NATHAN, M. I.

GA AS OPTICALLY COUPLED TRANSISTOR STRUCTURE WITH  
LASING EMITTER A66-12442

NATHAN, M. I.

CURRENT DISTRIBUTION CONTROL IN GALLIUM ARSENIDE  
INJECTION LASER SHOWING EFFECTS ON OSCILLATION  
MODE AND THRESHOLD A65-17665

NAUMOVA, L. V.

LASER WITH DIFFRACTION LIMITED RADIATION PATTERN  
A66-10450

LASER WITH DIFFRACTION LIMITED RADIATION PATTERN  
A66-13313

NEAL, R. A.

LASER ACTION AT 5401 ANGSTROMS IN PURE NEON PULSED  
HIGH VOLTAGE DISCHARGE A66-10353

NEELAND, J. K.

WATER COOLED RUBY LASER CONTINUOUSLY OPERATED AT  
ROOM TEMPERATURE USING ROD IN PUMPING CAVITY  
A65-19234

FREQUENCY SEPARATION BETWEEN TRANSVERSE MODES OF  
RUBY LASER MEASURED BY FABRY-PEROT  
INTERFEROMETER AND VERIFIED BY TRANSVERSE MODE  
SELECTION A65-27610

NEFFLEN, K. F.

GAS MIXTURES AND PRESSURES FOR OPTIMUM OUTPUT  
POWER OF RF-EXCITED HELIUM-NEON GAS LASERS AT  
632.8 NM A65-22620

WAVELENGTH OF 3S2-2P4 TRANSITION OF NEON MEASURED,  
USING HELIUM-NEON LASER A66-16387

ABSOLUTE WAVELENGTH STABILITY OF HELIUM-NEON LASER  
MEASURED BY DIRECT INTERFEROMETRIC COMPARISON WITH  
HG 198 STANDARD LAMP A66-22868

NEGRELLI, T. J.

PEAK IRRADIANCE OF OPTICAL PUMP AND TOTAL  
PUMP-ENERGY INCIDENT UPON LASER CRYSTAL  
DETERMINED, ACCOUNTING FOR TEMPERATURE VARIATION  
EFFECTS A66-18487

NEHRICH, R. B., JR.

STIMULATED EMISSION AT ROOM TEMPERATURE IN  
EUROPIUM CHELATE SOLUTION A65-21625

NELLES, M.

FOCUSED ENERGY TECHNIQUES FOR JOINING, INCLUDING  
LASER WELDING  
ASTME PREPRINT AD66-718 A66-24413

NELSON, H.

ROOM TEMPERATURE OPERATION OF PULSED GALLIUM  
ARSENIDE INJECTION LASER, AND IMPROVEMENT OF  
LASER DIODE STRUCTURE  
ECOM-01501-1 N66-20809

NELSON, P.

PULSED LASER-CREATED PLASMAS BY LIGHT ABSORPTION  
BY SKIN EFFECT A66-12975

IONIZATION UNDER LASER ACTION EXTENDED TO METALS  
AND DIELECTRICS, NOTING INFLUENCE ON THRESHOLDS  
A66-17065

NERGAARD, L. S.

APPLICATION, PROBLEMS AND STATE OF LOW NOISE  
AMPLIFIERS AND TRAVELING WAVE TUBES, MASER AND



- ADLER TUBES GAIN IN RADAR SYSTEMS  
A66-14123
- NESOR, H. R.  
ELECTRON BEAM AND HOLLOW CATHODE FLOAT-ZONE  
PROCESSES ANALYSIS FOR APPLICATION TO GROWTH OF  
LASER RUBY CRYSTALS  
AFCAL-65-908  
N66-21169
- NESTER, J. F.  
GROWTH AND ANNEALING OF OPTICAL MASER CRYSTALS AND  
SPECTROSCOPIC EVALUATION OF NEODYMIUM-DOPED  
GLASSES  
PE-TR-8110  
N66-17007
- NESTOR, O. H.  
GROWTH OF RUBY BOULES ON 60 DEGREE VERNEUIL RODS  
BY CZOCHRALSKI METHOD - LASER APPLICATION  
SRCR-65-1  
N65-27885
- GROWTH OF CUBIC PEROVSKITE CRYSTALS AS SYMMETRIC  
HOSTS FOR LASER DOPANT IONS  
SRCR-65-9  
N66-16824
- NEUMANN, D. B.  
GIANT PULSED LASER TO ILLUMINATE DISTANT TARGET  
WITH LIGHT PULSE OF ABOUT 60 NANOSECONDS  
A65-24781
- IMAGE FORMING IN ATMOSPHERIC SCATTERING MEDIUM  
WITH 60 NANOSECOND ILLUMINATING PULSE FROM  
Q-SWITCHED RUBY LASER  
AFAL-TR-64-278  
N65-25580
- NEUSTRUEV, V. B.  
EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING  
SPECTRAL RANGE, DURATION, ELECTRON EXCITATION  
MECHANISM AND UPPER WAVELENGTH LIMIT  
A66-19667
- EXCITED RUBY CRYSTAL PHOSPHORESCENCE NOTING  
SPECTRAL RANGE, DURATION, ELECTRON EXCITATION  
MECHANISM AND UPPER WAVELENGTH LIMIT  
A66-21834
- NEWSTEIN, M. C.  
PERTURBED AND PLANE PARALLEL FABRY-PEROT  
RESONATORS, THERMAL FIELDS, QUANTUM OPTICAL  
COHERENCE, SPONTANEOUS EMISSION, AND DYNAMICAL  
THEORY OF LASER OSCILLATION  
AFCL-65-270  
N65-27088
- NEWTON, J. F.  
INSTRUMENTATION TECHNIQUES FOR NEW TYPE OF GAS  
DENSITY MEASURING SYSTEM USING LIGHT SCATTERED  
FROM LASER BEAM AS MEASURED QUANTITY  
A66-15794
- NGUYEN-VAN-TRAM  
PARAMETRIC CONVERSION OF OPTICAL FREQUENCIES IN  
CRYSTAL ILLUMINATED BY LASERS  
A65-28626
- NICASTRO, L. J.  
MEASUREMENT OF ELECTRON DENSITY OF GAS DISCHARGE  
PLASMA BY LASER INTERFEROMETER  
A66-16379
- NICHOLLS, R. W.  
LABORATORY RESEARCH ON LASER EXCITATION IN SOLIDS,  
IONIZING RADIATION TRANSMISSION AND PLASMA JETS  
RELATED TO ASTROPHYSICS  
A65-14678
- SPECTROSCOPIC INVESTIGATION OF LASER EXCITED  
MOLECULAR SPECTRA FROM POWDERED SOLIDS FOR METEOR  
AND REENTRY PHYSICS  
A65-16382
- NICHOLSON, A. F.  
LASER RADAR WITH WIDE ANGLE FLOOD-LIGHTING  
LOPSIDED ENERGY BEAM FOR NEAR HORIZON USE WITH  
MINIMUM TERRAIN REFLECTIONS  
A65-23554
- NIEUWPOORT, W. C.  
CHEMICAL LASER WITH INPUT ENERGY DERIVED SOLELY  
FROM CHEMICAL REACTION PRODUCED RADIATION, NOTING  
PROCESS OF COHERENT LIGHT PRODUCTION  
A65-20001
- CHEMICAL LASER PRINCIPLE CONSIDERING POPULATION  
INVERSIONS FROM CHEMICAL REACTION  
A65-20002
- FLAME EMISSION DATA AND ABSORPTION CHARACTERISTICS  
SUITABLE FOR POPULATION INVERSION FOR LASER  
ACTION, NOTING LOW PRESSURE OXYACETYLENE FLAME  
A65-20070
- NIKITIN, V. V.  
LASER OUTPUT OF XENON-HELIUM MIXTURE AS FUNCTION  
OF CHARGE DURATION, GAS PRESSURE AND TUBE DIAMETER  
A65-20263
- OPTICALLY CONNECTED LASER CONSTRUCTED ON GALLIUM  
ARSENIDE P-N JUNCTION, NOTING COHERENT RADIATION  
A66-14363
- GALLIUM ARSENIDE P-N JUNCTION LASER DIODE COVERING  
INJECTION CURRENT DISTRIBUTION, DENSITY AND  
EMISSION SPECTRA VARIATION  
A66-14659
- NIKLAS, A.  
THERMOSTIMULATED INDUCED ELECTRON EMISSION FROM  
SAMPLES CUT FROM LASER RUBY CRYSTALS DETECTED WITH  
OPEN POINT COUNTER  
A66-18609
- NILSEN, W. G.  
MICROWAVE PROPERTIES PARTICULARLY LINEWIDTH AND  
MAGNETIC ANISOTROPY IN CALCIUM-VANADIUM BISMUTH  
GARNET, NOTING TWM ISOLATOR  
A65-24964
- NIMMIKHOFEN, J. D.  
LASER WELDING TECHNIQUE EXAMINING JOINT DESIGN,  
WELDABLE MATERIALS AND COSTS  
A65-32798
- NISHIKORI, K.  
UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE  
RUBY LASER TECHNIQUES, PRESENTING HEIGHT  
DISTRIBUTION CURVES OF SCATTERED LIGHT  
A66-13376
- NOLLE, E. L.  
CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION  
A66-11188
- FORCED EMISSION FROM ELECTRON-EXCITED CADMIUM  
SELENIDE  
A66-22174
- CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION  
A66-24009
- NORTH, W. P.  
GASEOUS AND RUBY LASERS AS LIGHT SOURCES FOR  
PHOTOELASTICITY  
TEAM-276  
N65-29794
- NORTH, W. P. T.  
DYNAMIC STRESS CONCENTRATION USING PHOTOELASTICITY  
AND RUBY LASER LIGHT SOURCE  
TEAM-285  
N66-20850
- NOVICK, G.  
RUBY LASER AMPLIFIER AT LIQUID-NITROGEN  
TEMPERATURE TREATED AS THREE-MEDIUM TRANSMISSION  
SYSTEM, NOTING GAIN CHANGE WITH NEGATIVE  
ATTENUATION  
A66-22867
- MULTIPLE REFLECTION THEORY APPLIED TO REGENERATIVE  
LASER AMPLIFIER DESIGN  
ECOM-2531  
N65-19166
- REGENERATIVE RUBY LASER AMPLIFIERS AT LIQUID  
NITROGEN TEMPERATURES  
ECOM-2575  
N65-35642
- NOVICK, R.  
SELF-SUSTAINED OSCILLATION OBTAINED IN OPTICALLY  
PUMPED RUBIDIUM MASER OPERATING AT TRANSITION  
FREQUENCY OF 6835 MC  
A65-21873
- OPTICALLY PUMPED RUBIDIUM 87 MASER OSCILLATOR  
A66-24124
- OPTICAL MASER APPLIED TO BRILLOUIN SCATTERING  
SPECTROSCOPY  
PR-3  
N65-13790
- OPTICAL MASER APPLIED TO BRILLOUIN SCATTERING  
SPECTROSCOPY  
AROD-3922-13  
N65-19528
- INVESTIGATIONS IN ASTRONOMY, SOLID STATE PHYSICS,

- OPTICAL MASERS, ATOMIC PHYSICS, AND RADIOACTIVE  
ATOMS FOR ELECTROMAGNETIC APPLICATIONS  
NASA-CR-70391 N66-17320
- NOVIKOVA, L. A.  
GAS LASER OUTPUT AND THRESHOLD IN POPULATION  
INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE  
AND FLUORO IODO METHYLIDYNE A66-16771
- NOVOTNY, A.  
OSCILLATION SPIKES IN QUASI-CONTINUOUS OPERATION  
OF RUBY LASER AT ROOM TEMPERATURE, NOTING  
THRESHOLD PUMPING ENERGY A66-17532
- NUESE, C. J.  
DIRECT-INDIRECT TRANSITION EFFECT ON HALL EFFECT  
IN GALLIUM /ARSENIC PHOSPHIDE/ A66-21570
- GROWTH OF GALLIUM ARSENIDE-PHOSPHIDE COMPOUNDS  
FOR LASER USE  
AFCL-65-271 N65-27833
- ZINC DIFFUSION IN GALLIUM ARSENIDE-PHOSPHIDE  
LASERS AND EFFECTS ON SEMICONDUCTOR JUNCTIONS  
AFCL-66-18 N66-22611
- NUGENT, L. J.  
MATERIAL TESTING FOR GAS LASER OSCILLATOR AND  
SOLID STATE CHELATE LASER - OPTICAL RADARS  
RADC-TR-64-526 N66-12838
- NUNEZ, J.  
ELECTRICAL SWITCHING OF EMISSION DIRECTION OF  
LASER OSCILLATOR BY INTERNAL DEFLECTION OF LASER  
BEAM A65-16403
- C W IR LASER OSCILLATION IN H BR AND HI GAS  
DISCHARGE A66-16756
- MUMIKHOVEN, J. D.  
PRODUCTION LASER WELDING OF INTRICATE AND CRITICAL  
SUBASSEMBLIES INCORPORATED INTO SPACE VEHICLES AND  
COMPONENTS A66-14514
- O
- OCKMAN, W.  
DOUBLE PHOTON ABSORPTION, HARMONIC GENERATION,  
AND FREQUENCY MIXING IN SEMICONDUCTORS, AND  
FREQUENCY TUNING OF INJECTION LASERS BY  
UNIAXIAL STRESS  
AD-450756 N65-14437
- ODINTSOV, A. I.  
HELIUM-NEON LASER OUTPUT CHARACTERISTICS AS  
FUNCTION OF LASER PARAMETERS A65-31375
- HELIUM-NEON LASER OUTPUT CHARACTERISTICS AS  
FUNCTION OF LASER PARAMETERS A66-14897
- EFFECT OF LOAD MISMATCH ON LASER OUTPUT,  
DETERMINING NONLINEAR DEPENDENCE OF EQUIVALENT  
NEGATIVE CONDUCTANCE AS FUNCTION OF OSCILLATION  
AMPLITUDE IN LASER RESONATOR CAVITY A66-20435
- OFFERHAUS, M. J.  
GEOMETRICAL PROPERTIES COMMON TO ALL MODES OF  
OSCILLATION IN RADIATION FIELD OF LASER  
INTERFEROMETERS A65-18795
- OGLAND, J. O.  
CATHODOLUMINESCENT PHOSPHORS AS LIGHT SOURCE FOR  
LASERS, REDUCING HEAT LIMITATIONS AND ELIMINATING  
INTERNAL STRESSES CAUSED BY THERMAL GRADIENTS  
A65-30436
- OGLAND, J. W.  
OPTICAL LASER PUMPS, HIGH POWER CW LASER  
OPERATION BY CATHODOLUMINESCENCE AND SUITABLE  
SELECTION OF PHOSPHORS A66-19546
- OHTSUKA, Y.  
MODE DEGENERACY-DIPS ON OUTPUT OF HE- NE LASER  
FOR CERTAIN CRITICAL COMBINATION OF MIRROR  
CURVATURES AND SEPARATION A65-36703
- OHTSUKI, O.  
RADIATIVE TRANSITION PROCESS IN EMISSION SPECTRUM
- OF GALLIUM ARSENIDE P-N JUNCTION LASER DIODES  
A65-34666
- OKAMOTO, H.  
PRESSURE DEPENDENCE OF OUTPUT OF HELIUM-NEON  
GASEOUS LASER IN HIGH PRESSURE RANGE A66-11375
- OKAYA, A.  
MODE SUPPRESSION AND MODE STABILIZATION OF HELIUM-  
NEON LASER, USING TUNGSTEN WIRES AS MODE  
DISCRIMINATOR A65-15325
- OKOONIAN, H. J.  
OPTICAL SECOND HARMONIC GENERATION APPLIED TO HIGH  
POWER COHERENT SOURCE FREQUENCY TRANSLATION IN  
COMMUNICATIONS SYSTEMS A65-19176
- OKMIT, S.  
SOLID STATE AND MASER TECHNIQUES - BREADBOARD  
EVALUATION, MEASUREMENTS OF LOW-TEMPERATURE  
SEMICONDUCTOR, AND SUPERCONDUCTING THIN FILM  
TUNNELING EFFECTS  
RADC-TDR-64-480 N65-16017
- DEVELOPMENT AND APPLICATION OF IMPROVED MASER  
TECHNIQUES FOR BROADBAND MASER SYSTEM -  
TRAVELING WAVE MASER TECHNIQUES  
RADC-TR-65-148 N65-32203
- SOLID-STATE AND TRAVELING-WAVE MASER TECHNIQUES  
RADC-TR-65-30 N65-33397
- BROADBAND TRAVELING WAVE MASER TECHNIQUES AND  
N-TYPE GERMANIUM SEMICONDUCTOR DEVELOPMENT  
RADC-TR-65-366 N66-15720
- OLIVIER, M.  
ZEEMAN EFFECT MODULATION OF AMMONIA MASER FOR  
FREQUENCY STANDARD N65-26685
- OLSEN, H. N.  
RADIATION SCATTERING FROM LASER BEAM BY FREE  
PLASMA ELECTRONS  
NSL-64-168-1 N65-20300
- OLSON, F. A.  
PHONON-PHOTON INTERACTIONS IN OPTICAL SOURCES -  
THEORETICAL DESCRIPTION OF BRAGG AND  
RAMAN- NATH SCATTERING CAUSED BY PROPAGATION OF  
PLANE ACOUSTIC WAVE THROUGH LASER BEAM PATH  
AFOSR-65-2647 N66-22449
- OLSON, R. S.  
EFFECT OF RUBY LASER ENERGY ON GAMMA RADIATED  
HUMAN ADENOCARCINOMA CELLS  
SAM-TR-65-41 N66-11874
- OMEARA, T. R.  
SINGLE RESONATOR REFLECTION AMPLIFIER ANALYSIS IN  
TERMS OF SCATTERING MATRIX DESCRIPTION OF OPTICAL  
RESONATOR A65-25885
- OPPENHEIM, A. K.  
ONSET OF RETONATION, LASER TECHNOLOGY AND HIGH  
REPETITION-HIGH RESOLUTION SCHLIEREN STROBOSCOPIC  
WAVE PHENOMENA RECORDS A66-19200
- ORAEVSKII, A. N.  
SELF-PULSED MODULATION MODE STABILIZATION OF TWO-  
LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK A65-14144
- SELF-PULSED MODULATION MODE STABILIZATION OF TWO-  
LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK A65-24019
- NATURAL MODES OF PLANE AND CYLINDRICAL DIELECTRIC  
RESONATORS IN OPTICAL BAND A65-24810
- PLASMA KINETIC PROCESSES IN NE- HE LASER LEADING  
TO POPULATION INVERSION A65-27738
- TIME DEPENDENCE OF LASER OPERATION MODES USING  
LASER MODEL WITH TWO OSCILLATION TYPES A65-27772
- PLASMA KINETIC PROCESSES IN NE- HE LASER LEADING  
TO POPULATION INVERSION A65-31843

- NONLINEAR INTERACTION OF OSCILLATIONS OF TWO TYPES IN LASER DOES NOT AFFECT STATIONARY OPERATION WHEN OSCILLATIONS ARE SUFFICIENTLY APART IN BAND  
A66-10724
- TIME DEPENDENCE OF LASER OPERATION MODES, USING LASER MODEL WITH TWO OSCILLATION TYPES  
A66-16626
- ORAYEVSKIY, A. N.  
MASER WITH TWO SERIES RESONATORS  
N65-13904
- CONFERENCE ON PHYSICAL PROBLEMS OF QUANTUM ELECTRONICS - NONLINEAR OPTICAL PHENOMENA, SEMICONDUCTOR LASERS, GAS DISCHARGES IN GAS LASERS, AND GAS BREAKDOWN IN LASER BEAM  
JPRS-34262  
N66-18135
- ORSZAG, A.  
EARTH-MOON DISTANCE MEASUREMENT USING LASER TECHNIQUE  
A66-20129
- OSHIMA, K.  
HE-NE GAS LASER APPLICATION TO SCHLIEREN PHOTOGRAPHY AND MACH-ZEHNDER INTERFEROMETRY IN AERODYNAMIC TESTING  
A65-22501
- NEON-HELIUM GAS LASER APPLICATION TO SCHLIEREN PHOTOGRAPHY AND MACH-ZEHNDER INTERFEROMETRY FOR USE IN AERODYNAMIC TESTING  
N65-21372
- OSHIMA, Y.  
HE-NE GAS LASER APPLICATION TO SCHLIEREN PHOTOGRAPHY AND MACH-ZEHNDER INTERFEROMETRY IN AERODYNAMIC TESTING  
A65-22501
- NEON-HELIUM GAS LASER APPLICATION TO SCHLIEREN PHOTOGRAPHY AND MACH-ZEHNDER INTERFEROMETRY FOR USE IN AERODYNAMIC TESTING  
N65-21372
- OSHMAM, M. K.  
GENERATION OF SINGLE FREQUENCY LIGHT USING FM LASER  
A65-16670
- SUPERMODE LASER AS SINGLE-FREQUENCY GENERATION SYSTEM CONSISTING OF FM LASER WITH SYNCHRONOUS PHASE MODULATOR AT OUTPUT  
A65-29267
- CONTROLLING FM AND SUPERMODE LASER OUTPUT FREQUENCIES BY THRESHOLD CONTROL AND INTERFEROMETRIC CONTROL  
A65-36842
- CARRIER FREQUENCY STABILIZATION OF FM LASER WITH RESPECT TO CENTER OF ATOMIC GAIN PROFILE, USING SMALL DISTORTION PRESENT IN LASER OSCILLATION  
A66-10966
- EXPERIMENTS ON HELIUM-NEON FM LASERS COVERING PHASE-LOCKED AND FM REGION POWER OUTPUT, MODULATION INDEX AND DISTORTION EXPERIMENTS  
A66-13955
- OSIAL, T. A.  
USE OF LASER BEAM IN SPECTROGRAPHIC ANALYSIS - NORMAL LASER AND GIANT SPIKE LASER  
AFRL-65-586  
N66-12799
- OSIKO, V. V.  
CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH NEODYMIUM IONS  
A65-31703
- CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH NEODYMIUM IONS  
A66-19956
- OSTROVSKII, L. A.  
LASER OSCILLATION AND ENERGY LOSSES IN MEDIUM CONTAINING ACTIVE MOLECULES  
A65-24811
- LASER MODEL POSSESSING TWO MODES OF DIFFERENT VIBRATIONAL FREQUENCY  
A65-26026
- LASER MODEL POSSESSING TWO MODES OF DIFFERENT VIBRATIONAL FREQUENCY  
A66-11728
- SELF-MODULATION OF LASER WITH TWO-MODE RESONATOR  
A66-16775
- OSTROVSKIY, L. A.  
STEADY STATE OSCILLATIONS OF LASERS WITH DISTRIBUTED ENERGY LOSSES  
N65-27236
- P**
- PAANANEN, R.  
GAS LASERS - LEVEL POPULATION DEPENDENCES, LASER POWER OUTPUT, METASTABLE DENSITY MEASUREMENTS, AND PARAMETER CHANGE EFFECT ON MATHEMATICAL MODEL OF LASER SYSTEM  
S-740  
N65-20002
- PAANANEN, R. A.  
I R LASER ACTION IN ARGON II BETWEEN 1 AND 2 MICRONS AND IN 6000 TO 7000 ANGSTROM RANGE  
A65-11207
- PALMOUR, H.  
LASER CRYSTAL GROWTH, CHARACTERIZATION, AND SURFACE FINISHING  
N65-17597
- PANAS, J. F.  
TRAVELING WAVE MASER SUPERCONDUCTING MAGNET COOLED IN CLOSED-CYCLE REFRIGERATOR BY THERMAL CONDUCTION  
A65-32128
- PANDARESE, F.  
COHERENTLY DRIVEN MOLECULAR VIBRATIONS AND LIGHT MODULATION - RAMAN SCATTERING BY MASER BEAM  
NASA-CR-58211  
N65-14531
- PANKOVE, J. I.  
TEMPERATURE DEPENDENCE OF EMISSION SPECTRUM AND THRESHOLD CURRENT IN GaAs LASERS  
A66-17333
- PANTELL, R. H.  
SUPPRESSING PULSED LASER SPIKING BY PROVIDING EQUILIBRIUM PHOTON DENSITY AS THRESHOLD IS REACHED, NOTING CASE OF RUBY LASER  
A65-21300
- LASER OSCILLATOR WITH EXTERNALLY APPLIED SIGNAL EMPHASIZING PUSHING-PULLING EFFECTS, POWER GAIN AND NATURAL OSCILLATION QUENCHING CONDITIONS  
A65-25861
- PANZER, S.  
LASER AS THERMAL TOOL IN METAL WORKING PROCESSES EXAMINING PHASE TRANSFORMATION  
A65-20005
- PAPOULAR, R.  
LASER BEAM-GAS INTERACTION INDUCED DISCHARGE STUDIED FOR THRESHOLD, BREAKDOWN AND EMITTED LIGHT CHARACTERISTICS  
A65-27084
- INTENSE LASER BEAM FOCUSING EFFECT IN GAS TO STUDY LIGHT-INDUCED DISCHARGES BY TIME-RESOLVED SPECTROSCOPY AND PHOTOGRAPHY  
A66-12978
- PAPULOVSKII, V. F.  
XENON-KRYPTON LASER EMISSION IN 12 WAVELENGTHS RANGING FROM 2.03 TO 9 MICRONS WITH EXTERNAL AND INNER MIRRORS  
A65-17353
- BEAM DIVERGENCE ANGLE OF SINGLE TEM MODE NE-HE LASER OUTPUT AT 0.63 MICRONS  
A65-27739
- BEAM DIVERGENCE ANGLE OF SINGLE TEM MODE NE-HE LASER OUTPUT AT 0.63 MICRONS  
A65-31844
- PARIKH, P.  
OPTICAL DOUBLE RESONANCE IN RUBY, DISCUSSING ABSORPTION TRANSITIONS FROM LOWEST EXCITED STATE OF CHROMIUM ION EFFECTED BY LASER PUMPING  
A66-20856
- PARISER, B.  
GAS LASER CROSS MODULATION EFFECT WHEN EXPOSED TO FLASH TUBE RADIATION  
A65-15324
- TIME DEVELOPMENT OF OUTPUT INTENSITY OF HE-NE LASER AFTER QUENCHING BY PUMPING PARTICLES INTO LOWER NEON LASER STATE  
A65-29075
- PARKER, A. K.  
GAS LASER RANGE MEASUREMENT DEVICE GIVING HIGH ACCURACY DIFFERENTIAL TERRAIN HEIGHT INFORMATION

- FROM AIRBORNE PLATFORM N65-33571
- PARKER, H. W.**  
REAL TIME, PROJECTION DISPLAY SYSTEM USING LASER  
LIGHT SOURCE  
U1-903600-1 N65-35989
- LARGE ANGLE DEFLECTION TECHNIQUE FOR PRODUCING  
945-LINE TELEVISION TYPE RASTER SCAN IN DISPLAY  
SYSTEM - ELECTRO-OPTICS, LASERS, AND FIBER  
OPTICS  
U1-912008-1 N66-14858
- LARGE-ANGLE DEFLECTION METHOD FOR PRODUCTION OF  
TV TYPE RASTER SCAN IN LASER DISPLAY SYSTEM  
U2-912008-2 N66-22498
- PARKS, J. A.**  
PHOTOTUBE OBSERVATION OF RUBY LASER OUTPUT  
AS FUNCTION OF TIME N65-15570
- PARKS, J. K.**  
WIDEBAND LASER BEAM MODULATION, USING BRAGG-  
ANGLE DIFFRACTION BY AMPLITUDE-MODULATED  
ULTRASONIC WAVES A65-29974
- PARKS, R. E.**  
SECOND HARMONIC LIGHT GENERATED ON REFLECTION OF  
GIANT-PULSE LASER BEAM FROM SURFACE OF SILVER  
MIRROR A66-16072
- PARSONS, M. L.**  
GASEOUS AND SOLID LASER LINES SURVEY FOR LASER  
SPECTROSCOPY AND PLASMA DIAGNOSTICS  
NASA-CR-57334 N65-19752
- PASCALAR, H. G.**  
RADIOMETRIC PERFORMANCE OF SOLID STATE  
SUPERHETERODYNE RECEIVER COMPARABLE TO THAT  
OBTAINED WITH MASERS AND PARAMETRIC AMPLIFIERS  
A66-12437
- PASHININ, P. P.**  
SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-14131
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING  
TOTAL REFLECTION PRISM A65-18462
- SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-24951
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING  
TOTAL REFLECTION PRISM A65-28091
- SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER  
RADIATION, DETERMINING TEMPERATURE OF PLASMA  
PRODUCED NEAR FOCUS A65-31705
- SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER  
RADIATION, DETERMINING TEMPERATURE OF PLASMA  
PRODUCED NEAR FOCUS A66-19959
- PASTOR, R. C.**  
GAIN COEFFICIENTS AND MEASUREMENTS IN LASER  
AMPLIFIER, AND SOLID STATE LASER MATERIALS  
QR-6 N65-14465
- IMPROVEMENT OF CRYSTAL QUALITY OF FLAME FUSION  
RUBY - LASER MATERIAL  
AL-TDR-64-195, PT. I N65-15848
- SOLID STATE LASER AMPLIFIER STRUCTURES  
QPR-8 N66-12048
- PULSED YTTRIUM-ALUMINUM GARNET NEODYMIUM LASER  
DEVICE - SOLID STATE LASER DEVICE  
QPR-9 N66-14725
- PATEL, C. K. N.**  
C W LASER OSCILLATION ON P BRANCH ROTATIONAL  
TRANSITIONS OF VIBRATION BAND OF NITROUS OXIDE  
A65-16671
- C W HIGH POWER OPERATION OF NITROGEN-CARBON  
DIOXIDE LASER OSCILLATING ON P-BRANCH ROTATIONAL  
TRANSITIONS OF VIBRATIONAL BAND OF CARBON DIOXIDE  
A65-33055
- HIGH POWER BREWSTER WINDOW LASER WITH GAS FILLS,  
DISCUSSING POWER OUTPUT AND EFFICIENCY PARAMETERS  
A66-13983
- C W GAS LASER, MEASURING VIBRATIONAL ROTATIONAL  
TRANSLATION FREQUENCIES OF CARBON MONOXIDE  
A66-13984
- C W LASER OSCILLATION BETWEEN 11.48 AND 11.55  
MICRONS FROM NITROGEN-CARBON DISULFIDE SYSTEM  
A66-16384
- C W HIGH-POWER CARBON DIOXIDE-NITROGEN-HELIUM  
LASER OPERATION, NOTING HELIUM ADDITION  
A66-16754
- LASER ACTION ON ROTATIONAL TRANSITIONS OF 10-9, 9-  
8, 8-7, 7-6 AND 6-5 VIBRATIONAL BANDS OF GROUND  
ELECTRONIC STATE CO A66-18424
- PATERSON, J. E.**  
USE OF LASER BEAM IN SPECTROGRAPHIC ANALYSIS -  
NORMAL LASER AND GIANT SPIKE LASER  
AFCL-65-586 N66-12799
- PATON, B. YE.**  
RUBY AND NEODYMIUM GLASS LASERS FOR INDUSTRY -  
ELECTRONICS N65-23722
- PATRICK, R. M.**  
THOMSON SCATTERING SPECTRUM OF LASER BEAM FROM  
EQUILIBRIUM HYDROGEN PLASMA, NOTING EFFECT OF  
DEBYE LENGTH A65-17151
- THOMSON SCATTERING MEASUREMENTS OF MAGNETIC  
ANNULAR SHOCK TUBE PLASMAS USING Q-SWITCHED RUBY  
LASER LIGHT BEAM A66-14707
- PAUL, W.**  
PRESSURE DEPENDENCE OF DOMINANT EMISSION MODES  
FROM Pb SE DIODE LASER A66-13003
- PAUTHIER, M.**  
TWO- AND THREE-STEP LASER CASCADES DETECTED  
EXPERIMENTALLY IN HELIUM-NEON MIXTURES, ANALYZING  
TWO-STEP CASCADE STARTING WITH DENSITY MATRIX  
FORMULATION A66-11477
- PAXMAN, D. H.**  
PUMP FREQUENCY OF 30 GIGACYCLES USING HARMONIC  
CROSS RELAXATION ON CHROMIUM DOPED RUTILE TO  
OBTAIN POPULATION INVERSION AT 40 GIGACYCLE  
SIGNAL FREQUENCY A65-25873
- PEDINOFF, M. E.**  
CARBON AND ETHYLENE TETRACHLORIDE ULTRASONIC  
MODULATORS APPLIED TO IR LASER HETERODYNE  
EXPERIMENTS ON IN AS PHOTODIODE A66-23353
- PELTZER, K. E.**  
EFFECTS OF PROPAGATION TIMES ON STEERING NARROW  
BEAM LASER FOR COMMUNICATIONS BETWEEN PLANETARY  
DEEP-SPACE VEHICLE AND EARTH GROUND STATION OR  
RELAY STATION - SPACIAL BEAM OFFSET  
NASA-TM-X-55306 N66-11202
- PENDLETON, W. K.**  
LASERS AS TRIGGERING MECHANISM FOR SPARK GAPS,  
NOTING DELAY TIME BETWEEN PULSE ARRIVAL AND  
CURRENT FLOW A66-13247
- PENFIELD, P., JR.**  
BRILLOUIN SCATTERING OF LIGHT BY PHONONS AND  
PHONON MASER IN DERIVATION OF CONSERVATION  
THEOREMS FROM BASIC EQUATIONS A66-18397
- PEREL, V. I.**  
QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION  
AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION  
A65-28487
- QUANTUM YIELD COEFFICIENT OF STIMULATED EMISSION  
AND ANGULAR DISTRIBUTION OF LASER DIODE EMISSION  
A66-12086
- DEPENDENCE OF EMISSION INTENSITY OF GAS LASER ON  
LONGITUDINAL AND TRANSVERSE MAGNETIC FIELDS, USING  
SIMPLIFIED MODEL A66-24885

- PERRY, D. L.**  
BROADBAND DIELECTRIC MIRRORS USED WITH PULSED GAS LASER TO OBSERVE LASER OSCILLATIONS IN VISIBLE WAVELENGTH REGION A65-16570
- LOW-LOSS MULTILAYER DIELECTRIC COATINGS BY FILM DEPOSITION FOR LASER MIRROR A65-29525
- PERRY, E. R.**  
LASER CURRENT-MONITORING DEVICE, SMALL CURRENT TRANSFORMER FEEDS SOLID-STATE PULSE-CODING DEVICE WHICH MODULATES GALLIUM-ARSENIDE LASER A65-29885
- PERSCHY, J. A.**  
RUBY LASER OPTICAL RADAR DETECTION OF UPPER ATMOSPHERIC BACKSCATTERING A66-24395
- PETERS, N.**  
DIRECT FREQUENCY COMPARISON OF ATOMIC HYDROGEN MASERS IN DIFFERENT PLACES AND CONDITIONS BY SIMULTANEOUS MONITORING OF LORAN C SIGNALS A66-24145
- PETERS, N. E.**  
HYDROGEN MASER AND CESIUM BEAM TUBE FREQUENCY STANDARDS COMPARED A65-16680
- FREQUENCY STANDARDS OF HYDROGEN MASER AND SWISS CESIUM ATOMIC BEAM TUBE COMPARED A65-16681
- HYDROGEN MASER CONSTRUCTION AND OPERATION DESIGN PRINCIPLES EMPHASIZING MICROWAVE CAVITY, LOW MAGNETIC FIELD, HYDROGEN STORAGE AND MASER TUNING TECHNIQUES A65-24309
- HYDROGEN MASER RESETTABILITY VERIFYING BY MEASURING MASER OUTPUT FREQUENCY AGAINST HYDROGEN PRESSURE, CONSIDERING EXCHANGE COLLISION AND WALL INTERACTIONS A65-29119
- ATOMIC HYDROGEN MASER FOR TIME AND FREQUENCY MEASUREMENTS - TIME COMPARISONS ON MASERS WITH LORAN C N65-26678
- PETRASH, G. G.**  
PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J AND N TO K CALCULATED WITH GAS LASER A65-21811
- LASER PULSE GENERATION WITH PLASMA RESULTING FROM DISCHARGE IN HYDROGEN AS MEDIUM A65-22728
- PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J AND N TO K CALCULATED WITH GAS LASER A65-24863
- PETROV, IU. N.**  
HELIUM-XENON AND KRYPTON-XENON GAS LASERS OPERATING IN FAR IR A65-26727
- PETROV, V. S.**  
Q-SWITCHING OF ND LASER USING POLYMETHINE DYE IN METHYL ALCOHOL SOLVENT A65-27533
- PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER A66-10262
- PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER A66-13307
- PETROV, V. YE.**  
AMMONIA MASER - AMMONIA MOLECULAR GENERATOR FTD-TT-65-803/16264 N66-19855
- PEYTON, B. J.**  
LOW NOISE KA-BAND TRAVELING WAVE MASER AMPLIFIER FOR WINDOW AT 8 MM WHERE ATMOSPHERIC ATTENUATION IS LOW A65-16565
- PFLUGER, A. R.**  
LASER BEAM WELDING ELECTRONIC-COMPONENT LEADS A66-14517
- PHELPS, A. V.**  
IONIZATION BREAKDOWN MECHANISMS OF GASES AT OPTICAL INFRARED FREQUENCIES USING LASERS RADC-TDR-64-422 N65-18624
- PHILBERT, M.**  
LASER OUTPUT MEASUREMENT BY PHOTOELECTRIC CELL DEVICE, NOTING CALIBRATION ONERA TP 182 A65-19066
- LASER PHOTOMETRY THROUGH PHOTOELECTRIC CELL ONERA-TP-182/1964/ N65-28499
- PHILBRICK, C. R.**  
CO-60 GAMMA IRRADIATION INDUCED ENERGY OUTPUT INCREASE OF RUBY LASER CRYSTAL A65-17687
- GAMMA RADIATION EFFECT ON ENERGY OUTPUT OF RUBY LASER CRYSTALS N65-17596
- PICARD, R. H.**  
COHERENCE PROPERTIES OF INTERACTING SYSTEM OF RADIATION AND MATTER EXHIBITING LASER-LIKE BEHAVIOR, NOTING SELF-CONSISTENT-FIELD APPROXIMATION / SCFA/ USE FOR MANY-BODY EFFECTS A65-27725
- PILIPETSKII, N. F.**  
SPATIAL AMPLITUDE OF FIELD OF IDEALLY PARALLEL LASER BEAM FOCUSED BY OPTICAL SYSTEMS WITH SPHERICAL ABERRATION A66-23778
- PILKUMN, M.**  
ELECTROLUMINESCENCE OF ZINC DIFFUSED DIODES IN FORWARD AND REVERSE BIAS, OBSERVING EMISSION SPECTRA AND LASING ACTION IN NEAR-EDGE LINE A65-21617
- PILKUMN, M. H.**  
SELF-INDUCED OSCILLATIONS IN OUTPUT OF FABRY-PEROT GALLIUM ARSENIDE INJECTION LASER A65-21624
- OPTICAL GAIN AND LOSSES OF GA AS LASER OF EPITAXIAL AND DIFFUSED TYPE A65-33380
- RISE OF JUNCTION TEMPERATURE DURING CONTINUOUS OPERATION OF GA AS INJECTION LASER A66-14771
- PILTCH, M.**  
LASER ACTION ON FIVE GREEN LINES AND SIX IR LINES CAUSED BY PULSING MANGANESE DISCHARGE OF COLLISION LASER IN ATOMIC VAPOR OF NEUTRAL MANGANESE A66-16763
- PIMENOV, IU. P.**  
TRANSITION PROCESSES OF OSCILLATION AMPLITUDE FORMATION IN RF THREE-LEVEL MASERS A65-15460
- MASER APPLICATIONS AS RADIO RECEIVERS, DISCUSSING MULTIRESONATOR ALL-PASS QUANTUM AMPLIFIERS A65-16282
- MASER APPLICATIONS AS RADIO RECEIVERS, DISCUSSING MULTIRESONATOR ALL-PASS QUANTUM AMPLIFIERS A65-25785
- TRANSITION PROCESSES OF OSCILLATION AMPLITUDE FORMATION IN RF THREE-LEVEL MASERS A65-28556
- PINCUS, G.**  
ISOLATION OF 1.0621 LINE IN HE- NE GAS LASER BY MULTILAYER DIELECTRIC-COATED MIRRORS WITH SHARP SPECTRAL CUT-OFF CHARACTERISTICS A66-20517
- PITCHER, G.**  
PHOTOELECTRONS EMITTED BY PHOTOCATHODE LIT BY HEAT SOURCE AND LASER COUNTING NUMBER OF AVALANCHES DURING GIVEN TIME A65-18037
- ACCURATE LOCATION OF OBJECT IN SPACE AND TIME AND CORRECTION OF MOVEMENTS BY USE OF QUANTUM ELECTRODYNAMICS A65-25036

## PISAREVSKII, I. V.

FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS SYSTEMS, PRIMARILY LIGHT ABSORPTION AND ATMOSPHERIC SCATTERING A65-15349

FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS SYSTEMS, PRIMARILY LIGHT ABSORPTION AND ATMOSPHERIC SCATTERING A65-32353

## PISKAREV, V. I.

CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY LASER A65-35866

CORRELATION FACTOR FOR INDUCED RADIATION FREQUENCY SHIFTS AND CRYSTAL TEMPERATURE VARIATIONS IN RUBY LASER A66-19269

## PISKARSKAS, A. S.

OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-15352

OPTICAL RANGE PARAMETRIC AMPLIFICATION, DESCRIBING POWER OUTPUT EXPERIMENT WITH GLASS-LASER-EXCITED POTASSIUM DIHYDROGEN PHOSPHATE CRYSTAL A66-20893

## PLASS, G. N.

LASER RADIATION ABSORBED ALONG SLANT PATHS, SPECTRAL LINE OVERLAPPING AND CENTER LINE SHIFT WITH PRESSURE VARIATION A66-17295

## PLOOSTER, M. N.

GROWTH OF RUBY BOULES ON 60 DEGREE VERNEUIL RODS BY CZOCHRALSKI METHOD - LASER APPLICATION SRCR-65-1 N65-27885

## PLOTKIN, H. H.

REFLECTED RADIATION OF Q-SPOILED RUBY LASER FROM EXPLORER XXII A65-21306

ACCURATE TRACKING OF BEACON- EXPLORER ORBITING OPTICAL REFLECTORS, USING PULSED RUBY LASER BEAMS A66-19902

SATELLITE REFLECTOR DESIGN FOR LASER BEAM RETROREFLECTION AND SATELLITE SIGNAL TRANSMISSION CALCULATIONS NASA-TM-X-55129 N65-18254

LASER BEAM TRACKING OF BEACON EXPLORER SATELLITES NASA-TM-X-56631 N66-22191

## PODGAETSKII, V. M.

MEASUREMENT OF RADIATION PATTERN OF RUBY LASER EMISSION FOR VARIOUS RESONATORS AND OPERATING REGIMES, NOTING LASER EFFECT ON ANGULAR HALF-WIDTH VALUES A66-22028

## POGODA, A. L.

NARROW BAND LASER DOPPLER RADAR NAVIGATION INSTRUMENT FOR INSTANTANEOUS GROUND SPEED TRG-019-I-1 N65-27932

DOPPLER OPTICAL NAVIGATOR TO MEASURE INSTANTANEOUS GROUND SPEED WITH 0.1 FT/SEC ACCURACY FOR ALTITUDES OF 250 TO 5000 FEET - CONTINUOUS WAVE LASER AS TRANSMITTER TRG-019-1-2 N65-28160

## POGORELII, O. M.

RADIATION FLUCTUATIONS IN LASER PULSE REGIME, DISCUSSING ERRORS ARISING IN COMPARING BASIC WITH SECONDARY EMISSION A65-14617

## POGORELYI, O. M.

DISPERSION RESONATOR PERFORMANCE IN RUBY LASER, SHOWING GENERATION OF R SUB 1 AND R SUB 2 LINES A66-16346

DISPERSION RESONATOR PERFORMANCE IN RUBY LASER, SHOWING GENERATION OF R SUB 1 AND R SUB 2 LINES A66-22345

## POKASOV, V. V.

HELIUM-NEON LASER OUTPUT DEPENDENCE ON HOLLOW

CATHODE DISCHARGE CONDITIONS FOR ELECTRON TRANSITIONS IN NEON A65-25591

HELIUM-NEON LASER OUTPUT DEPENDENCE ON HOLLOW CATHODE DISCHARGE CONDITIONS FOR ELECTRON TRANSITIONS IN NEON A66-11422

## POKORNY, G.

HIGH INTENSITY ULTRAVIOLET RADIATION SOURCE TO PUMP PHOSPHORS AND LASER MATERIALS WITH ABSORPTION BANDS IN PHOSPHOR EMISSION SPECTRUM ODRF-173 N65-14365

## POLANYI, J. C.

PARTIAL AND COMPLETE VIBRATIONAL-ROTATIONAL POPULATION INVERSION CONDITIONS, DISCUSSING VIBRATIONAL STATE CHANGE IN PHYSICAL AND CHEMICAL PROCESSES A65-20067

## POLANYI, T. G.

OUTPUT OF SINGLE MODE GAS LASER IN AXIAL MAGNETIC FIELD STUDIED FOR INCREASE IN FREQUENCY STABILITY A65-26954

## POLE, R. V.

ELECTRICAL SWITCHING OF EMISSION DIRECTION OF LASER OSCILLATOR BY INTERNAL DEFLECTION OF LASER BEAM A65-16403

CONJUGATE-CONCENTRIC LASER RESONATOR WITH SIMPLE IMAGING SYSTEM GEOMETRY DISCUSSING PROPERTIES, EIGENVALUE PROBLEM AND FILTERING FUNCTIONS A65-18206

LASER DEFLECTION AND SCANNING BY MEANS OF MULTIMODE CAVITIES WITH DYNAMIC SPATIAL FILTERS A66-14829

## POLLACK, M. A.

HE- NE GAS LASER OSCILLATING IN TWO LINEARLY POLARIZED MODES, COMPARING THEORETICAL AND EXPERIMENTAL MODE INTENSITIES AND BEAT FREQUENCIES A65-32844

## POLTORATSKII, E. A.

GALLIUM ARSENIDE LUMINESCENT DIODES WITH TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION AT HIGH DENSITY CURRENT A65-36787

GALLIUM ARSENIDE LUMINESCENT DIODES WITH TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION AT HIGH DENSITY CURRENT A66-19195

## POMERANTZ, M.

PHONON INTERACTION IN CRYSTALS - TRANSIENTLY OPERATED ACOUSTIC MASER, INTERACTION OF PHONONS WITH IMPURITIES IN GERMANIUM AND SILICON, AND HEAT PULSES IN CRYSTALS CTR-7 N65-27746

SIGNAL VELOCITY OF MASERS, AND MICROWAVE PHONON ATTENUATION AND PULSED HEAT RADIATION IN SINGLE CRYSTAL SEMICONDUCTORS REPT.-8 N65-36734

## POPOV, A. K.

GAS LASER EMISSION SOLUTION BY DETERMINING EMISSION FIELD DENSITY DEPENDENCE ON RESONATOR PARAMETERS, RELAXATION CHARACTERISTICS AND ATOM EXCITATION IN GAS DISCHARGE PLASMA A65-35868

GAS LASER EMISSION SOLUTION BY DETERMINING EMISSION FIELD DENSITY DEPENDENCE ON RESONATOR PARAMETERS, RELAXATION CHARACTERISTICS AND ATOM EXCITATION IN GAS DISCHARGE PLASMA A66-19271

## POPOV, I. V.

POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR A65-36058

POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR A66-15861

## PORTO, S. P. S.

BUILDUP AND DECAY TRANSIENT EFFECTS IN GAS LASERS

- DUE TO LIGHT ABSORPTION BY INSERTED LIQUID SAMPLES  
A65-15816
- POTENZA, G.  
PARAMETRIC DEPENDENCE OF TIME PROFILE, PEAK POWER  
AND NUMBER OF GIANT PULSES OF ROTATING PRISM  
Q-SWITCHED LASERS A65-15103
- EMISSION CHARACTERISTICS OF Q-SWITCHED RUBY LASER  
WITH SATURABLE ABSORBER A65-35053
- POULIQUEN, J.  
PERIODIC VARIATION OF QUALITY FACTOR OF HE- NE  
GAS LASER CAVITY BY VIBRATING QUARTZ-MODULATION OF  
LIGHT BEAM A66-13477
- POULTNEY, S. K.  
RUBY LASER OPTICAL RADAR DETECTION OF UPPER  
ATMOSPHERIC BACKSCATTERING A66-24395
- PRATESI, R.  
QUASI-CONTINUOUS EMISSION OR REGULAR RELAXATION  
OSCILLATIONS FROM MANY-ELEMENT RUBY LASER  
OPERATING IN VERY FEW AXIAL MODES A65-19619
- LASER CAVITY ANALYSIS, THRESHOLD MEASUREMENTS,  
FREQUENCY DISTRIBUTION, MODE DENSITY, AND  
SPIKING STRUCTURE  
AFCRL-65-481 N65-32298
- PRATT, W. K.  
LASER COMMUNICATION SYSTEMS STUDY  
FR-64-19-301 N65-17940
- PREHMUS, G. F.  
PHOTOGRAPHIC STUDY OF Q-SWITCHED LASER BEAM  
PROPAGATING OVER 10-MILE PATH A65-31044
- PRESTON, K., JR.  
OPTICAL ANALOG COMPUTER TRANSPOSING VARIABLE  
INPUTS INTO SPATIAL DIMENSIONS, USING LASER AS  
LIGHT SOURCE FOR ANTENNA MODELING AND SPECTRUM  
ANALYSIS A65-33770
- PRINGLE, W. R.  
PREPARATION OF OPTICALLY HOMOGENEOUS LASER GLASS  
FREE OF PLATINUM INCLUSIONS BY PLATINUM  
PASSIVATION OR USING ALL-CERAMIC MELTING SYSTEM  
SATR-1 N65-22027
- PRINGLE, W. R.  
PREPARATION OF PLATINUM-FREE LASER GLASS  
SATR-2 N66-14672
- PROKHINDEEV, A. V.  
SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-14131
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING  
TOTAL REFLECTION PRISM A65-18462
- SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-24951
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING  
TOTAL REFLECTION PRISM A65-28091
- PROKHODOV, A. M.  
MULTIPHOTON ABSORPTION IN LASER GA AS AND RUBY  
CRYSTAL OF OPTICAL GENERATOR A65-26025
- PROKHOROV, A. M.  
SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-14131
- MASER AMPLIFIER WITH COUPLED ACTIVE RESONATORS  
OPERATING AT 21 CM WAVELENGTH, NOTING ADVANTAGE  
OVER PASSIVE INPUT CIRCUIT A65-14136
- TRANSITION PROCESSES OF OSCILLATION AMPLITUDE  
FORMATION IN RF THREE-LEVEL MASERS A65-15460
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING  
TOTAL REFLECTION PRISM A65-18462
- EMISSION SPECTRUM OF RUBY LASER WITH EXTERNAL  
SPHERICAL MIRRORS IN NONDAMPING INTENSITY
- FLUCTUATIONS AND QUASI-STEADY GENERATION A65-21041
- MASER AMPLIFIER WITH COUPLED ACTIVE RESONATORS  
OPERATING AT 21 CM WAVELENGTH, NOTING ADVANTAGE  
OVER PASSIVE INPUT CIRCUIT A65-24011
- LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING  
FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM  
ION IN VARIOUS CONCENTRATIONS A65-24881
- SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-24951
- QUANTUM ELECTRONICS HISTORICAL REVIEW COVERING  
DIFFICULTIES ENCOUNTERED IN LASER/MASER  
CONSTRUCTION A65-25256
- HELIUM-XENON AND KRYPTON-XENON GAS LASERS  
OPERATING IN FAR IR A65-26727
- RUBY LASER WITH MODULATED Q-FACTOR USING ROTATING  
TOTAL REFLECTION PRISM A65-28091
- TRANSITION PROCESSES OF OSCILLATION AMPLITUDE  
FORMATION IN RF THREE-LEVEL MASERS A65-28556
- CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT  
ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH  
NEODYMIUM IONS A65-31703
- SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER  
RADIATION, DETERMINING TEMPERATURE OF PLASMA  
PRODUCED NEAR FOCUS A65-31705
- LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING  
FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM  
ION IN VARIOUS CONCENTRATIONS A65-36358
- DYSPROSIUM DOPED CALCIUM FLUORIDE DOPED LASER,  
USING SOLAR RADIATION FOR EXCITATION AND OPERATING  
AT 77 DEGREES K A65-36361
- RUBY LASER RADIATION EFFECT ON FLUORESCENCE AND  
LASER ACTION IN DYSPROSIUM DOPED CALCIUM FLUORIDE  
CRYSTALS A66-10718
- MULTIPHOTON ABSORPTION IN LASER GA AS AND RUBY  
CRYSTAL OF OPTICAL GENERATOR A66-11727
- CD S SINGLE CRYSTAL OPTICAL GENERATOR DURING  
EXCITATION BY RUBY LASER, DISCUSSING TWO-PHOTON  
ABSORPTION COEFFICIENT AT 300 DEGREES K FOR  
RADIATION FLUX DENSITIES A66-13874
- LASER REGIME WITH GIANT PULSES GENERATED IN  
DYSPROSIUM DOPED CADMIUM FLUORIDE UNDER CONTINUOUS  
PUMPING BY XENON LAMPS, OBTAINING C FACTOR  
MODULATION BY ROTATING PRISM A66-19376
- CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT  
ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH  
NEODYMIUM IONS A66-19956
- SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER  
RADIATION, DETERMINING TEMPERATURE OF PLASMA  
PRODUCED NEAR FOCUS A66-19959
- PROKOPIUK, M. F.  
THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-19669
- THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-21836
- PROTSENKO, E. D.  
HELIUM-NEON LASER RADIATION DISPERSION MEASUREMENT  
IN TRANSITION 3S2-2P4 FOR VARYING MIRROR SPACING  
A65-19693
- PROTSENKO, YE. D.  
RADIATION DIVERGENCE MEASUREMENT IN HELIUM-NEON  
LASERS WITH CONFOCAL RESONATORS AND SPHERICAL  
REFLECTORS N65-24550

**PUTHOFF, H. E.**  
SUPPRESSING PULSED LASER SPIKING BY PROVIDING  
EQUILIBRIUM PHOTON DENSITY AS THRESHOLD IS  
REACHED, NOTING CASE OF RUBY LASER  
A65-21300

**Q**

**QUANG, D. N.**  
LASER BEAM-GAS INTERACTION INDUCED DISCHARGE  
STUDIED FOR THRESHOLD, BREAKDOWN AND EMITTED LIGHT  
CHARACTERISTICS  
A65-27084

INTENSE LASER BEAM FOCUSING EFFECT IN GAS TO  
STUDY LIGHT-INDUCED DISCHARGES BY TIME-RESOLVED  
SPECTROSCOPY AND PHOTOGRAPHY  
A66-12978

**QUATE, C. F.**  
COHERENT LIGHT DIFFRACTION BY MICROWAVE SOUND IN  
TRANSPARENT CRYSTALS  
A65-29265

**QUESADA, A. F.**  
CHROMIUM ALIGNMENT IN RUBY BY OPTICALLY PUMPING  
RUBY SAMPLE WITH CIRCULAR POLARIZED RADIATION FROM  
RUBY LASER  
A65-33418

FABRY-PEROT INTERFEROMETRIC MODULATOR FOR LASER  
BEAM, NOTING ERROR OF PRECISE ALIGNMENT OF  
REFLECTING SURFACES AND GAUSSIAN TYPE OF  
IMPERFECTIONS  
A66-12202

**QUIST, T. M.**  
CIRCUITRY, MECHANICAL CONSTRUCTION AND PRELIMINARY  
PERFORMANCE OF GALLIUM ARSENIDE LASER TRANSMITTER  
OPERATED AT ROOM TEMPERATURE  
A65-15327

**R**

**RABINOVICH, M. S.**  
FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD  
OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK  
SHOCK WAVE IN LASER BEAM  
A66-10263

FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD  
OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK  
SHOCK WAVE IN LASER BEAM  
A66-13308

**RABINOWITZ, P.**  
FREQUENCY STABILIZATION IN VISIBLE SPECTRUM OF  
GAS LASER USED AS OPTICAL PUMP GAIN MODULATOR  
NASA-CR-64359  
N65-31013

**RABSON, T. A.**  
POLARIZATION OF LIGHT FROM GLASS LASER DOPED WITH  
TWO PERCENT POSITIVE TRIVALENT NEODYMIUM MEASURED  
WITH TIME RESOLUTION OF LESS THAN MICROSECOND  
A66-13006

**RACETTE, G. W.**  
PARAMETRIC GAIN ACCOMPANYING PARAMETRIC  
AMPLIFICATION OF LIGHT BEAM BY SECOND HARMONIC  
FREQUENCY OF STIMULATED RADIATION FROM RUBY LASER  
ADP CRYSTALS  
A65-24280

HIGH POWER LASER BEAM COLLINEARIZATION USING  
BIREFRINGENCE OF UNIAXIAL CALCITE CRYSTAL PRISM  
A65-25828

SECOND HARMONIC LIGHT GENERATION, STRESSING  
SATURATION EFFECTS OCCURRING AT HIGH LASER POWER  
LEVELS, SOLVING NONLINEAR COUPLED MAXWELL  
EQUATIONS  
A66-11443

**RADO, W. G.**  
STIMULATED BRILLOUIN AND RAMAN SCATTERING IN  
GASES, DISCUSSING SOUND VELOCITY CALCULATION FROM  
FREQUENCY SHIFT AND ARGON, HYDROGEN AND NITROGEN  
A66-13981

LASER INDUCED GAS BREAKDOWN AT HIGH PRESSURES,  
NOTING EFFECT OF PLASMA DENSITY ON INDEX OF  
REFRACTION VIA OPTICAL FREQUENCY RESONANCE  
MEASUREMENT  
A66-21564

**RAIZER, I. U. P.**  
SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER  
RADIATION, DETERMINING TEMPERATURE OF PLASMA  
PRODUCED NEAR FOCUS  
A65-31705

BREAKDOWN OF GASES UNDER INFLUENCE OF LASER SPARK  
PHENOMENA WITH SUBSEQUENT ABSORPTION OF LASER  
RADIATION AND GAS HEATING  
A66-10646

SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER  
RADIATION, DETERMINING TEMPERATURE OF PLASMA  
PRODUCED NEAR FOCUS  
A66-19959

**RAMACHANDRAN, T. B.**  
MICROWAVE BEATS IDENTIFIED BETWEEN MODES IN  
BROMINE-ARGON MIXTURE  
A66-14923

**RAMSEY, N. F.**  
HYDROGEN MASER CONSTRUCTION AND OPERATION DESIGN  
PRINCIPLES EMPHASIZING MICROWAVE CAVITY, LOW  
MAGNETIC FIELD, HYDROGEN STORAGE AND MASER TUNING  
TECHNIQUES  
A65-24309

ATOMIC HYDROGEN MASER FOR MEASURING RF AND  
MICROWAVE SPECTRAL LINES DISCUSSING THRESHOLD,  
RELAXATION, FREQUENCY STABILITY AND HYPERFINE  
STRUCTURE  
A65-26934

**RANDALL, J. L.**  
RESEARCH REVIEW OF OPTICAL TRACKING, GUIDANCE, AND  
COMMUNICATION STUDIES AT MSFC  
N66-23457

**RANK, D. H.**  
GAS SPECTROSCOPY OF LASER-INDUCED STIMULATED  
BRILLOUIN EFFECT IN HIGH PRESSURE OXYGEN  
A66-23432

POWER AND PATH LENGTH EFFECTS ON STIMULATED RAMAN  
SPECTRA IN METHANE AND HYDROGEN STUDIES USING  
GIANT PULSED LASER  
N66-20037

**RASHBA, E. I.**  
SEMICONDUCTOR PULSE MASER BASED ON THEORY OF  
EXISTENCE OF ELECTRODIPOLE TRANSITIONS WITH SPIN  
ORIENTATION SHIFTS  
A65-20909

**RATNER, A. M.**  
POLARIZED LASER RADIATION WITH RELATION BETWEEN  
INTENSITY AND DIPOLE MOMENT OF ANISOTROPY AND  
PUMPING POWER  
A65-21805

POLARIZED LASER RADIATION WITH RELATION BETWEEN  
INTENSITY AND DIPOLE MOMENT OF ANISOTROPY AND  
PUMPING POWER  
A65-24857

OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF  
SOLID STATE LASER AND COMPENSATION VIA LENS IN  
RESONATOR  
A65-36051

OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF  
SOLID STATE LASER AND COMPENSATION VIA LENS IN  
RESONATOR  
A66-15854

**RAUTIAN, S. G.**  
NOBLE GAS-OXYGEN LASER OPERATION UNDER O13 TRIPLE  
P EXCITATION THROUGH COLLISION-INDUCED OXYGEN  
DISSOCIATION, NOTING BANDWIDTHS AND OSCILLATIONS  
A65-21810

PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J  
AND N TO K CALCULATED WITH GAS LASER  
A65-21811

NOBLE GAS-OXYGEN LASER OPERATION UNDER O13  
TRIPLE P EXCITATION THROUGH COLLISION-INDUCED  
OXYGEN DISSOCIATION, NOTING BANDWIDTHS AND  
OSCILLATIONS  
A65-24862

PROBABILITIES OF SPONTANEOUS TRANSITIONS M TO J  
AND N TO K CALCULATED WITH GAS LASER  
A65-24863

**RAY, R. D.**  
IMPROVED MASER PERFORMANCE THROUGH GAIN STABILITY  
IF PUMP FLUCTUATIONS ARE KEPT TO MINIMUM BY  
ELIMINATION OF TWO OF FOUR VARIABLES  
A65-21324

**RAYNOR, F. A.**  
FREQUENCY RESPONSE AND CROSS COUPLING OF RED AND  
IR GAS LASER INTERFEROMETER FOR MEASURING PLASMA  
ELECTRON DENSITY  
A65-15819



- READ, A. A.**  
SMALL PARTICLE DETECTION CAPABILITY OF LOW-GAIN  
HELIUM-NEON GAS LASER ENHANCED BY USE OF STOKES  
SETTLING LAW AND LAYERED SEDIMENTATION TECHNIQUE  
A66-14583
- READY, J. F.**  
SINGLE PULSES OF ELECTRON EMISSION PRODUCED BY  
SPINNING-PRISM Q-SWITCHED RUBY LASER  
A65-15443
- HEATING AND VAPORIZATION EFFECTS DUE TO HIGH POWER  
LASER BEAM ABSORPTION AT OPAQUE SURFACES, NOTING  
ALSO Q-SWITCHED LASERS  
A65-17663
- LASER RADIATION EFFECTS AND APPLICATION NOTING  
POWER OUTPUT, MELTING, VAPORIZATION AND SURFACE  
EMISSION  
A65-31764
- INTERACTION MECHANISM BETWEEN LASER BEAM AND  
SURFACE IN ULTRAHIGH VACUUM  
A66-15484
- REDIKER, R. H.**  
INDIUM ARSENIIDE DIODE SPONTANEOUS AND LASER  
ELECTROLUMINESCENCE IN MAGNETIC FIELDS  
A65-24961
- PB SE DIODE LASER FABRICATION, PROPERTIES AND  
EMISSION SPECTRUM WITH PEAK AT 0.5 MICRONS  
A65-27602
- LASER ACTION AT LIQUID HELIUM TEMPERATURE IN  
CRYSTALS OF LEAD SAMARIUM, LEAD SELENIDE AND LEAD  
TELLURIDE EXCITED BY FAST ELECTRON BEAM  
A65-30346
- PRESSURE DEPENDENCE OF DOMINANT EMISSION MODES  
FROM PB SE DIODE LASER  
A66-13003
- REDLIEB, H. W.**  
FEASIBILITY OF SINGLE-MODE MACROSCOPIC OPTICAL  
WAVEGUIDES AND COMPONENTS OPERATING AT  
MICROWAVE FREQUENCIES FOR ADVANCED LASER  
SYSTEMS  
NASA-CR-60527  
N65-16252
- MACROSCOPIC WAVEGUIDE AND WAVEGUIDE COMPONENTS FOR  
OPTICAL SYSTEMS - LASERS  
NASA-CR-332  
N66-16086
- REDLIEB, H. W., JR.**  
MODE IMPURITY OBSERVED IN DIFFRACTION MEASUREMENTS  
EMPLOYING GAS LASER APPARENTLY RESONATING IN  
TEM-00 MODE  
A65-16571
- OPTICAL SIMULATION OF MICROWAVE ANTENNAS WITHOUT  
DIRECT FREQUENCY SCALING, OBTAINING AMPLITUDE  
DISTRIBUTION OF LASER RADIATION FIELDS  
A65-29418
- REDMOND, P.**  
INTERACTION OF INTENSE LASER BEAMS WITH MATERIALS  
AROD-4157-4  
N65-27555
- REICH, A.**  
LARGE-ANGLE NONMECHANICAL SCANNING OF LIGHT IN ONE  
AND TWO DIMENSIONS THROUGH OPTICAL REFRACTION BY  
TRAVELING ACOUSTIC WAVES  
A65-21326
- REICH, S.**  
DOPPLER OPTICAL NAVIGATOR TO MEASURE  
INSTANTANEOUS GROUND SPEED WITH 0.1 FT/SEC  
ACCURACY FOR ALTITUDES OF 250 TO 5000 FEET -  
CONTINUOUS WAVE LASER AS TRANSMITTER  
TRG-019-1-2  
N65-28160
- REICK, F. G.**  
OPTICAL WHISPERING MODE OF POLISHED CYLINDERS AND  
IMPLICATION IN LASER TECHNOLOGY, NOTING TRAPPED  
FLUORESCENT LIGHT  
A66-12203
- REMPER, R. C.**  
GAS LASER RANGE MEASUREMENT DEVICE GIVING HIGH  
ACCURACY DIFFERENTIAL TERRAIN HEIGHT INFORMATION  
FROM AIRBORNE PLATFORM  
N65-33571
- RENAU, J.**  
CROSS SECTION MEASUREMENT FOR ELECTROMAGNETIC  
BACKSCATTERING OF LASER BEAMS FROM ROUGH ALUMINUM  
AND MAGNESIUM OXIDE SURFACES  
A66-18930
- REYNOLDS, R. S.**  
HELIUM-NEON LASER WITH HIGH SPECIFIC POWER FOR  
USE WITH OPTICAL TRACKING SYSTEMS AT 6328 Å  
NASA-CR-68589  
N66-13349
- RHODES, C. K.**  
VIBRATIONAL AND ROTATIONAL RELAXATIONS IN CARBON  
DIOXIDE AND NITROUS OXIDE LASER SYSTEMS, USING Q-  
SWITCHING TECHNIQUES  
A66-23355
- RIBEN, A. R.**  
MINORITY CARRIER LIFETIME IN SILICON MEASURED BY  
CONTACTLESS METHOD, USING LASER INDUCED MODULATION  
OF IR TRANSMISSION IN SILICON / LIMIRIS/ EFFECT  
A66-14563
- RICHARDS, F. A.**  
TIME RESOLUTION OF ELECTRON AND ION EMISSION  
PRODUCED BY Q-SWITCHED RUBY LASER PULSE FOCUSED  
ON METAL SURFACE  
A66-18358
- RICHARDS, W. E.**  
ALUMINUM NITRATE POWDER MASER DOPED WITH FERRIC  
IONS OPERATION IN X-BAND WITHOUT EXTERNAL DC  
MAGNETIC FIELD  
A66-11374
- ZERO FIELD X-BAND MASER DESIGN FOR MICROWAVE  
QUANTUM AMPLIFIERS - MILLIMETER AND  
SUBMILLIMETER WAVE DEVICES  
REPT.-490F  
N65-25851
- MILLIMETER AND SUBMILLIMETER MASER DEVICES -  
MEASURING TECHNIQUES FOR ZERO FIELD MASER  
REPT.-490G  
N65-33895
- RICHMOND, J. C.**  
LASER SOURCE REFLECTOMETER TO MEASURE REFLECTANCE  
OF SPECIMENS AT HIGH TEMPERATURE - RELATION OF  
THERMAL EMISSION TO OTHER OPTICAL PROPERTIES  
NBS-TN-267  
N66-22418
- RIEDEL, E. P.**  
ORGANIC CATIONS EFFECT ON LASER THRESHOLD OF  
SOLUTIONS OF TETRAKIS FORM OF EUROPIUM  
BENZOYLTRIFLUOROACETONATE  
A66-18418
- HEAVY WATER USED AS LIQUID LASER SOLVENT FOR HIGH  
RADIANCE LIQUID LASER SYSTEMS AND RESEARCH IN  
OUTPUT BEAM DIVERGENCE, SPECTRAL NARROWING, AND  
THRESHOLDS FOR LASER ACTION  
AD-610714  
N65-27886
- THERMAL OPTICAL DISTORTION MEASUREMENTS FOR  
NEODYMIUM DOPED GLASS LASER ROD  
MDE-6236  
N66-22419
- RIGDEN, J.**  
C W LASER ACTION IN CARBON DIOXIDE-HELIUM MIXTURES  
A66-16385
- RIGDEN, J. D.**  
METALLIC PLASMA TUBE FOR ION LASERS ALLOWS THEM TO  
RUN AT HIGHER CURRENT DENSITIES THAN WITH CERAMIC  
TUBES  
A66-11373
- RIGROD, W. W.**  
STABILITY PARAMETER, SPOT SIZE AND WAVE FRONT  
CURVATURE OF GAUSSIAN BEAM IN RING RESONATOR  
CONTAINING UP TO FOUR UNEQUALLY SPACED SPHERICAL  
MIRRORS  
A65-24910
- CALCULATION OF RADIATION INTENSITY OBTAINED FROM  
LASER WITH HOMOGENEOUS LINE BROADENING GENERALIZED  
FOR ARBITRARILY LARGE LOSS FRACTION PER PASS  
A65-32219
- TRAVELING WAVE OSCILLATIONS OF ION RING LASER IN  
MIRROR-RING RESONATOR  
A66-14903
- OUTPUT SPECTRA OF ARGON ION LASER IN RING  
RESONATOR AND TWO MIRROR RESONATORS  
A66-14904
- RILEY, L. W.**  
STIMULATED EMISSION FROM CHROMIUM IONS IN Q-  
SPOILED RUBY LASER  
A65-35066

- RINEHART, R. E.**  
EVALUATION OF MASER-EQUIPPED WEATHER RADAR SET AND AREA PRECIPITATION MEASUREMENT INDICATOR - METEOROLOGICAL SENSING DEVICE - ELECTRONICS QPR-1 N66-14191  
MASER EQUIPPED WEATHER RADAR AND PRECIPITATION MEASUREMENT INDICATOR QPR-2 N66-19957
- RISKEN, H.**  
NONLINEAR THEORY OF LASER NOISE WITH CORRELATION FUNCTIONS DERIVED FROM DISTRIBUTION FUNCTIONS OBTAINED BY FOKKER-PLANCK EQUATION A65-27759  
CORRELATION FUNCTIONS OF AMPLITUDE AND INTENSITY FLUCTUATION FOR LASER MODEL NEAR THRESHOLD OBTAINED BY USING DISTRIBUTION FUNCTIONS EVALUATED BY FOKKER-PLANCK EQUATION, TREATING AMPLITUDE AS RANDOM VARIABLE A66-25018
- RITSCHL, R.**  
SELECTIVE REFLECTION AND DISPERSION PATTERNS NEAR RED RUBY LINES, USING RUBY LASER AS LIGHT SOURCE A65-33587
- RIVLIN, L. A.**  
COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE FABRY-PEROT RESONATOR A65-24088  
COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE FABRY-PEROT RESONATORS A65-34909
- RIVOIRE, G.**  
COHERENCE AND STIMULATION THRESHOLD OF STOKES LINE A66-18648
- ROBBIANI, R. L.**  
MASER PREAMPLIFIER DESIGNED INTO X-BAND WEATHER RADAR SET INCREASED RADAR SENSITIVITY BY 12.5 DECIBELS TO OVERALL 118.5 DECIBELS A66-13688
- ROBINSON, C. C.**  
EXCITED STATE SATURABLE ABSORBER USED WITH 1.06 MICRON NEODYMIUM GLASS LASER RADC-TR-65-369 N66-15701
- ROBINSON, F. N. H.**  
QUANTUM MECHANICS OF SIGNALS AND NOISE IN ATTENUATORS AND MASER AMPLIFIERS, RELATING EXPECTATION VALUES AND THERMAL STATE OF SYSTEM A65-30510
- ROCARD, J. M.**  
TRAVELING FIELDS IN INTERACTION OF IONIZED GASES WITH ELECTROMAGNETIC FIELD CURRENTS CHECKING LORENTZ FORCE AND MAGNETIC INDUCTION A66-12980
- ROCK, N. H.**  
GAS LASER CONTINUOUS WAVE AMPLIFIER USING RECTANGULAR CROSS SECTION DISCHARGE TUBE, NOTING OPERATION AS CW OSCILLATOR AND PULSE AMPLIFIER A65-16406
- ROCKMAN, A. G.**  
COMPARISON OF UNDERWATER ATTENUATION OF RUBY LASER LIGHT WITH NONLASER LIGHT NRL-6181 N65-28158
- RODOA, J. L.**  
EXPERIMENTAL OSCILLATION OF TWO LASERS AT SAME FREQUENCY WITH PHASE DIFFERENCE OF LESS THAN ONE THIRD DEGREE A65-19603
- RODOT, M.**  
STIMULATED EMISSION IN INDIUM ARSENIDE SHOWS EXCITATION THRESHOLD LOW AND LIGHT EMISSION HIGHLY DIRECTIONAL A66-17026
- ROESS, D.**  
CONICAL EMISSION IN RUBY LASERS WITH EXTERIOR MIRRORS A66-14278  
MODES OF EMISSION-VS-TIME SPECTRUM, OPTICAL EMISSION SPECTRUM AND SUPERPOSITION SPECTRUM OF SHORT CONFOCAL RUBY LASER IN NEAR FIELD A66-14290  
SPATIAL DISTRIBUTION OF HOLLOW-CONE SHAPED EMISSION OF MODES WHICH ARE TOTALLY REFLECTED IN NEODYMIUM-GLASS LASERS A66-14291  
MODE SELECTIVE CHARACTERISTICS OF PLANE-PARALLEL DIELECTRIC PLATE AS REFLECTOR FOR RUBY LASER RESONATOR A66-14330  
MODE OF OPERATION OF VARIOUS RUBY LASERS WITH PLANE-PARALLEL MIRRORS AT ROOM TEMPERATURE A66-14500  
TIME DEPENDENT EMISSION BEHAVIOR OF SINGLE AXIAL MODE OF DIFFRACTION LIMITED RUBY LASER AT ROOM TEMPERATURE A66-20420  
ROOM TEMPERATURE QUASI-CONTINUOUSLY PUMPED RUBY GIANT PULSE LASER WITH SATURABLE ABSORBER Q-SWITCH A66-21248
- ROGERS, G. L.**  
FLARE IMAGES ROLE IN SELF-DESTRUCTION OF LENS IN STRONG LASER BEAM A65-32228
- ROGERS, J.**  
LASER RANGING VIA DIGITAL COUNTER COUPLED PHOTOMULTIPLIER TUBE, NOTING SPECTRAL RESPONSE, GAIN TRANSIT TIME DEPENDENCE, OUTPUT COUPLING AND EFFECTIVE CATHODE DIAMETER A66-23759
- ROIG, J.**  
INTERFERENCE PHENOMENON OF SERRATED SYSTEM OF RINGS SURROUNDING CENTRAL BEAM OF GAS LASER ANALYZED, USING HELIUM NEON TUBE PLACED BETWEEN TWO EXTERIOR MIRRORS A66-17064
- ROLLIN, R. A., JR.**  
SPACE-TO-SPACE AND EARTH-TO-SPACE COMMUNICATION SYSTEMS USING LASER SOURCES RADC-TDR-64-289 N66-22582
- ROM-KRICHEVSKAIA, I. A.**  
OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF SOLID STATE LASER AND COMPENSATION VIA LENS IN RESONATOR A65-36051  
OPTICAL-MISALIGNMENT EFFECT ON THRESHOLD POWER OF SOLID STATE LASER AND COMPENSATION VIA LENS IN RESONATOR A66-15854
- ROMCHI, L.**  
THEORETICAL STUDY OF RESONANT MODES OF LASER CAVITY WITH END MIRRORS AND PERIODIC REFLECTIVITY AFCRL-64-1015 N65-17931  
LASER CAVITY ANALYSIS, THRESHOLD MEASUREMENTS, FREQUENCY DISTRIBUTION, MODE DENSITY, AND SPIKING STRUCTURE AFCRL-65-481 N65-32298
- ROSENBLUM, J. E.**  
HIGH POWER MERCURY LASER OPERATIONS IN KRYPTON AND ARGON AS FUNCTION OF MAGNETIC FIELD QPR-2 N65-22323
- ROSENBAUM, F. J.**  
DIELECTRIC CAVITY MASER COMPOSED OF RUBY ROD SEPARATING METAL PLATES, NOTING STRENGTH SATURATION BEHAVIOR, POWER OUTPUT, ETC A66-21308  
STEADY STATE VALUE OF INVERTED POPULATION, POWER OUTPUT, THRESHOLD BEHAVIOR AND SPIKING CHARACTERISTICS FOR SINGLE-MODE LASER WHEN RADIATION INTENSITY HAS SPATIAL DEPENDENCE A66-24562
- ROSS, M.**  
SEARCH VIA LASER RECEIVERS FOR INTERSTELLAR COMMUNICATIONS A66-16669  
HIGH SENSITIVITY FAST-RESPONSE LASER DETECTION SYSTEM, DESCRIBING MICROWAVE RESPONSE PHOTOELECTRIC DETECTOR WITH AMPLIFICATION AND

PERSONAL AUTHOR INDEX

SAKAI, Y.

- MIXING FUNCTIONS A66-22046
- ROSSETTI, C.  
LINEAR COEFFICIENT OF AMPLIFICATION OF CARBON  
DIOXIDE SUBJECTED TO HF EXCITATION FIELD FOR  
LASER EMISSION A66-12003
- ROTH, A. L.  
BALLOON-BORNE XENON LIGHT OPTICAL BEACON FOR  
LASER AND OPTICAL TRACKING, AND MISSILE-BORNE  
XENON OPTICAL BEACON FOR OPTICAL TRACKING  
B-3068 N65-31897
- ROTH, H.  
CURRENT-VOLTAGE CHARACTERISTICS OF CW X-BAND  
GA AS MICROWAVE GUNN GENERATOR A66-23029
- ROUNDS, D. E.  
EFFECT OF RUBY LASER ENERGY ON GAMMA RADIATED  
HUMAN ADENOCARCINOMA CELLS  
SAM-TR-65-41 N66-11874
- ROUZER, L. E.  
LINE WIDTHS AND INVERSION RATIOS OF IRON DOPED  
RUTILE FOR SUITABILITY IN BROADBAND MASERS  
A65-19622
- LINE WIDTH AND INVERSION RATIOS OF IRON-DOPED  
RUTILE FOR OPTICAL MASER APPLICATIONS  
NASA-TM-X-54754 N65-29390
- ROME, R. L.  
CONVENTIONAL FLOW VISUALIZATION USING LASER LIGHT  
SOURCE  
AIAA PAPER 66-127 A66-17104
- ROWLEY, W. R. C.  
WAVELENGTH MEASUREMENT OF HELIUM-NEON LASER  
EMISSION BY DOUBLE-CHANNEL RECORDING  
INTERFEROMETER, USING KRYPTON-86 PRIMARY STANDARD  
A66-22874
- ROY, E. L.  
ATMOSPHERIC EFFECTS ON LASER ENERGY PROPAGATION -  
LITERATURE SURVEY  
RE-TR-65-3 N65-23622
- ROZANOV, N. N.  
NONLINEAR ZEEMAN EFFECT FOR GAS LASER  
A66-19638
- RUBIN, P. L.  
NOBLE GAS-OXYGEN LASER OPERATION UNDER O13 TRIPLE  
P EXCITATION THROUGH COLLISION-INDUCED OXYGEN  
DISSOCIATION, NOTING BANDWIDTHS AND OSCILLATIONS  
A65-21810
- NOBLE GAS-OXYGEN LASER OPERATION UNDER O13  
TRIPLE P EXCITATION THROUGH COLLISION-INDUCED  
OXYGEN DISSOCIATION, NOTING BANDWIDTHS AND  
OSCILLATIONS A65-24862
- RUBINOV, A. N.  
RUBY LASER NOISE RADIATION CONSISTING OF INCREASED  
LUMINESCENCE AND Laterally DISPERSED GENERATION  
DETERMINED FROM ENERGY LEVEL POPULATIONS  
A65-35863
- RADIATION SCATTERING FACTOR DETERMINATION FOR RUBY  
LASER A65-36013
- RUBY LASER NOISE RADIATION CONSISTING OF INCREASED  
LUMINESCENCE AND Laterally DISPERSED GENERATION  
DETERMINED FROM ENERGY LEVEL POPULATIONS  
A66-16628
- RUDOLPH, O. B.  
INEXPENSIVE SIMPLIFIED CONSTRUCTION OF DC POWERED  
HELIUM NEON LASER WITH 6328 ANGSTROM OUTPUT  
A65-19849
- RUNDLE, W. J.  
GALLIUM ARSENIDE LASER DIODES FABRICATED BY  
DIFFUSION OF ZINC  
QPR-1 N65-17442
- RUPPRECHT, H.  
ELECTROLUMINESCENCE OF ZINC DIFFUSED DIODES IN  
FORWARD AND REVERSE BIAS, OBSERVING EMISSION  
SPECTRA AND LASING ACTION IN NEAR-EDGE LINE  
A65-21617
- OPTICAL GAIN AND LOSSES OF GA AS LASER OF  
EPITAXIAL AND DIFFUSED TYPE A65-33380
- RUPPRECHT, H. S.  
RISE OF JUNCTION TEMPERATURE DURING CONTINUOUS  
OPERATION OF GA AS INJECTION LASER A66-14771
- RUSSELL, J. P.  
FIRST ORDER RAMAN SCATTERING MEASUREMENT IN  
SILICON USING 6328-ANGSTROM OUTPUT OF HELIUM-NEON  
LASER A65-26457
- HELIUM-NEON GAS LASER USED IN RAMAN SPECTROSCOPY  
A66-19232
- RUTZ, R. F.  
CURRENT DISTRIBUTION CONTROL IN GALLIUM ARSENIDE  
INJECTION LASER SHOWING EFFECTS ON OSCILLATION  
MODE AND THRESHOLD A65-17665
- GA AS OPTICALLY COUPLED TRANSISTOR STRUCTURE WITH  
LASING EMITTER A66-12442
- RYACHEVA, E. S.  
LASER OSCILLATION IN CALCIUM TUNGSTATE CRYSTALS  
ACTIVATED WITH TRIVALENT PRASEODYMIUM  
A66-14898
- RYKALIN, N. N.  
ESTIMATION OF ENERGY PARAMETERS OF LASER LIGHT  
BEAM USED TO WELD METALS A65-30071
- HEATING PROCESS IN LASER WELDING OF METAL SHEETS,  
TAKING INTO ACCOUNT ENERGY DISTRIBUTION, HEAT  
TRANSFER AND FLUX DENSITIES A66-15347
- ESTIMATION OF ENERGY PARAMETERS OF LASER LIGHT  
BEAM USED TO WELD METALS A66-17626
- S**
- SABERSKY, A.  
COHERENT TRANSFER CHARACTERISTICS OF OPTICAL  
SYSTEM, HOLOGRAMS AND COMPLEX SPATIAL FILTERS,  
AND LASER APPLICATIONS  
D-5210-72-T80-110 N65-21691
- SABURI, A.  
TRAVELING-WAVE TUBE WITH PHOTOELECTRIC CATHODE  
USED AS DEMODULATOR FOR LASER COMMUNICATION  
A65-14345
- SACCHI, C. A.  
E-LEVEL POPULATION IN RUBY ROD AS FUNCTION OF PUMP  
ENERGY EMITTED BY FLASH TUBE A65-28013
- RUBY LASER OUTPUT EXHIBITING REGULAR SPIKES  
A66-10324
- SPIKING BEHAVIOR OF MULTIMODE RUBY LASER IN  
SPHERICAL RESONATOR, INTERPRETING NEAR-FIELD  
PATTERNS, FREQUENCY SPECTRUM, ETC  
A66-21311
- SAITO, S.  
TRAVELING-WAVE TUBE WITH PHOTOELECTRIC CATHODE  
USED AS DEMODULATOR FOR LASER COMMUNICATION  
A65-14345
- NOISE BEHAVIOR OF POTENTIAL MINIMUM OF TRAVELING  
WAVE TUBES AND REDUCTION FACTOR FOR SHOT NOISE  
DETERMINED, USING LASERS A65-26936
- SAJI, M.  
SHIFT OF EMISSION SPECTRUM IN PULSED GA AS LASER,  
NOTING WAVEFORM CHARACTERISTICS  
A66-14974
- RADIATION DAMAGE AND ANNEALING OF GALLIUM ARSENIDE  
LASER DIODE A66-14979
- SAKAI, Y.  
RUBY LASER OSCILLATIONS MODULATED BY ULTRASONIC  
VIBRATION A65-19623

## SAKHAROVA, N. A.

RUBY LASER THRESHOLD PUMPING AND EMISSION ENERGIES  
RELATED TO TRANSMISSION COEFFICIENT, ROD DIAMETER  
AND THRESHOLD LEVEL A65-20343

## SALAT, A.

ANGULAR WIDTH AND INTENSITY OF LIGHT FROM TWO  
LASERS THAT CAUSE PLASMA TO OSCILLATE AND IN TURN  
ARE SCATTERED BY INDUCED FLUCTUATIONS A66-14328

## SALON, H.

GALLIUM ARSENIDE INJECTION LASER FOR PROLONGED  
OPERATION AT LIQUID NITROGEN TEMPERATURES A66-10369

## SAMUELSON, H.

LASER ACTION IN RARE EARTH CHELATES, EMPHASIZING  
CHEMISTRY AND SPECTROSCOPIC PROPERTIES OF  
MATERIALS AND PROPERTIES OF LIQUID LASER A65-20074

EMISSION SPECTRA OF TRIS AND TETRAKIS FORMS OF  
FOUR BETA-DIKETONE EUROPIUM CHELATES STUDIED FOR  
LIQUID LASER APPLICATION A65-33308

CHELATE LASER SYSTEMS - EUROPIUM BENZOYLACETONATE  
TR-64-052.7 N65-14405

RARE EARTH CHELATE LASERS N65-15508

EMISSION SPECTROSCOPY AND COORDINATION CHEMISTRY  
OF EUROPIUM CHELATE SOLUTIONS - CHELATE LASERS  
INVESTIGATED FOR EVALUATING POTENTIALITIES OF  
LIQUID LASERS N66-14177

COORDINATION AND CHEMICAL EQUILIBRIUM IN CHELATE  
LASER MATERIALS N66-20730

## SAMPSON, D. F.

OXYGEN AS CAUSE OF SCATTERING AND CONVERSION OF  
IMPURITIES TO HIGHER VALENCE STATE IN CALCIUM  
FLUORIDE LASER SYSTEM A65-30800

## SAMSON, A. M.

MASER PEAK PULSE CHARACTERISTICS DURING  
INSTANTANEOUS SWITCHING OF INTERFEROMETER WHEN  
LOSS FACTOR RAPIDLY DECREASES A65-23004

## SANTOS, R.

CHORIORETINAL LESIONS PRODUCED BY LASER ON MONKEY  
AND RABBIT A66-80950

## SARFATT, J.

ATOMIC RELAXATION AND FLUCTUATIONS OF LASER  
PHOTONS DETERMINED BY ADDING PROBABILITY  
AMPLITUDES A65-20744

## SARGENT, M., III

EQUATIONS DESCRIBING HEAT FREQUENCY VARIATION AND  
MODE COMPETITION IN GASEOUS LASER OPERATED IN  
MAGNETIC FIELD PARALLEL TO LASER AXIS A65-30303

## SARZHEVSKII, A. M.

OUTPUT POWER AND PULSE DURATION OF RUBY LASER  
A66-12602

## SASAKI, M.

PULSED RUBY LASER OUTPUT MEASUREMENT BY OPTICAL  
BOLMETER A65-18017

## SAUERMANN, H.

SOLID STATE LASER SYSTEM, DESCRIBING QUANTUM  
MECHANICAL TREATMENT OF SELF-SUSTAINED OSCILLATION  
FOR ONE MODE A66-17817

## SAVAGE, A.

VELOCITY MATCHED SECOND HARMONIC GENERATION / SHG/  
AND MIXING OBTAINED IN PIEZOELECTRIC LITHIUM  
NIOBATE CRYSTALS A65-19235

## SAVCHENKO, M. M.

FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD  
OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK  
SHOCK WAVE IN LASER BEAM A66-10263

FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD

OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK  
SHOCK WAVE IN LASER BEAM A66-13308

## SAVVA, V. A.

MASER PEAK PULSE CHARACTERISTICS DURING  
INSTANTANEOUS SWITCHING OF INTERFEROMETER WHEN  
LOSS FACTOR RAPIDLY DECREASES A65-23004

## SCHAFFER, P. S.

VAPOR PHASE GROWTH OF RUBY SINGLE CRYSTALS FOR  
LASER APPLICATIONS AD-629154 N66-23875

## SCHANLOW, A. L.

DESIGN, OPERATION AND UTILIZATION OF LASER  
A65-29867

INTENSE UV PUMPING EFFECT ON RUBY LASER OUTPUT  
A66-20519

OPACITY MEASUREMENT OF XENON FLASH TUBE - OPTICAL  
MASER NASA-CR-56917 N65-35256

## SCHEGGI, A. M.

MICROWAVE MODELS USED TO MEASURE FREQUENCY AND  
QUALITY FACTORS OF FABRY-PEROT RESONATOR WITH  
PLANE SQUARE MIRRORS OPERATING IN X-BAND A66-14909

THEORETICAL STUDY OF RESONANT MODES OF LASER  
CAVITY WITH END MIRRORS AND PERIODIC  
REFLECTIVITY AFCL-64-1015 N65-17931

MICROWAVE MODELS OF OPTICAL RESONATORS - LASER OR  
MICROWAVE RESONATOR WITH FLAT ROOF MIRRORS -  
OPEN LASER RESONATORS RESEARCH AFCL-65-568 N65-34155

## SCHIEL, E. J.

DATA PULSED TRANSMISSION OVER ELECTRON-INJECTION  
LASER COMMUNICATION SYSTEM, USING CONTINUOUS WAVES  
A66-19934

HELIUM-NEON GAS LASER DIRECT MODULATION

N65-22300

## SCHIFFNER, G.

CURRENT DISCHARGE OF HELIUM NEON LASER ON LASER  
ACTION A66-12439

## SCHIMITSCHER, E. J.

STIMULATED EMISSION AT ROOM TEMPERATURE IN  
EUROPIUM CHELATE SOLUTION A65-21625

## SCHINELLER, E. R.

FEASIBILITY OF SINGLE-MODE MACROSCOPIC OPTICAL  
WAVEGUIDES AND COMPONENTS OPERATING AT  
MICROWAVE FREQUENCIES FOR ADVANCED LASER  
SYSTEMS NASA-CR-60527 N65-16252

MACROSCOPIC WAVEGUIDE AND WAVEGUIDE COMPONENTS FOR  
OPTICAL SYSTEMS - LASERS NASA-CR-332 N66-16086

## SCHLAFFER, J.

SYSTEM FOR OPTICAL ACQUISITION AND TRACKING, AND  
LASER BEAM DEFLECTOR DEVICES - ELECTRO-OPTICAL  
TECHNIQUES FOR CONTROLLING DIRECTION OF LASER  
BEAM FLOW NASA-CR-64222 N65-30541

PIEZOELECTRICALLY POWERED LASER BEAM WAVEGUIDE FOR  
ELECTRO-OPTICAL ACQUISITION AND TRACKING  
NASA-CR-68895 N66-17291

## SCHLEUSENER, S. A.

SMALL PARTICLE DETECTION CAPABILITY OF LOW-GAIN  
HELIUM-NEON GAS LASER ENHANCED BY USE OF STOKES  
SETTLING LAW AND LAYERED SEDIMENTATION TECHNIQUE  
A66-14583

## SCHLICKMAN, J. J.

STIMULATED EMISSION EVIDENCE FROM NITROGEN COOLED  
SPIKING RUBY-LASER-IRRADIATED DEGENERATED P-TYPE  
GA AS CRYSTALS A65-15323

- PULSED LASER DOSIMETER THAT MEASURES DANGER LEVEL OF RADIATION OF DIRECT OR REFLECTED BEAMS AS SAFEGUARD TO EYE DAMAGE A65-21951
- SCHMIDT, A. O.  
LASER WELDING EVALUATED WITH REGARD TO PERFORMANCE AND PRODUCTION APPLICATION A66-14692
- SCHMIDT, S.  
INTERFERENCE EFFECTS AT THIN TRANSPARENT CYLINDRICAL GLASS FIBERS EXPOSED TO COHERENT LIGHT FROM HE-NE LASER A66-10368
- SCHMIDT, P. A.  
FLASH PHOTOLYSIS APPARATUS FOR STUDYING SHORT LIVED CHEMICAL INTERMEDIATES FROM METHYLENE BLUE PSL-102 N66-21833
- SCHOEN, G. A.  
LARGE-ANGLE NONMECHANICAL SCANNING OF LIGHT IN ONE AND TWO DIMENSIONS THROUGH OPTICAL REFRACTION BY TRAVELING ACOUSTIC WAVES A65-21326
- SCHOENFELD, M.  
RADIO STATION FACILITIES AT RAISTING, WEST GERMANY NOTING SATELLITE COMMUNICATION, MASER RECEIVING SYSTEM, PARABOLIC ANTENNAS, ETC A65-35195
- SCHOTLAND, R. M.  
MEASUREMENT OF VERTICAL WATER VAPOR PROFILES BY MEANS OF THERMALLY TUNED RUBY LASER OPTICAL RADAR SYSTEM - HUMIDITY MEASUREMENT REPT.-65-6 N66-14852
- SCHROEDER, J. B.  
GROWTH AND ANNEALING OF OPTICAL MASER CRYSTALS AND SPECTROSCOPIC EVALUATION OF NEODYMIUM-DOPED GLASSES PE-TR-8110 N66-17007
- SCHULTEN, G.  
NORMAL BOLTZMANN DISTRIBUTION INVERSION IN MOLECULAR BEAM TO OBTAIN EXCESS UPPER ENERGY LEVEL POPULATION FOR MASER OSCILLATION A65-15801
- SCHULTZ, H.  
GAIN COEFFICIENTS AND MEASUREMENTS IN LASER AMPLIFIER, AND SOLID STATE LASER MATERIALS QR-6 N65-14465
- SCHULTZ, J.  
EFFECT OF LASER RADIATION ON CHEMICAL ACTIVATION AND VAPOR FOG NUCLEATION MC-64-110-R1 N65-27760
- SCHWARTZ, S. E.  
PHOTOMULTIPLIER AS LASER MONITOR EVALUATED IN TERMS OF PROBABILITY DENSITY FUNCTION A65-26828
- SCHWARTZ, W. G., JR.  
DISPERSION OF 1.15 MICRON HE-NE LASER LINE RESULTING FROM NEON ABSORPTION TRANSITION A65-31762
- SCHWENKER, R. P.  
Q-SPOILED RUBY LASER BEAM FOCUSED ON GRAPHITE, OBTAINING SWAN EMISSION OF CARBON MOLECULE A65-34207
- SCHWIDER, I.  
SELECTIVE REFLECTION AND DISPERSION PATTERNS NEAR RED RUBY LINES, USING RUBY LASER AS LIGHT SOURCE A65-33587
- SCHWINGHAMER, R. J.  
HIGH POWERED LASERS AND LASER WELDING NASA-TM-X-53285 N65-28961
- SCOTT, A. C.  
SINGLE MODE OUTSIDE DIFFERENTIAL QUANTUM EFFICIENCIES OF CIRCULAR AND RECTANGULAR LASER DIODES COMPARED A65-21321
- INSTABILITY IN LASER AMPLIFIER MEDIUM OCCURRING AT HIGH PUMPING LEVELS, GIVING TRANSMISSION LINE EQUIVALENT CIRCUIT FOR PLANE WAVE PROPAGATION A65-25888
- SINGLE MODE LASER EFFICIENCY AT HIGH PUMP LEVELS AS FUNCTION OF PUMPING RATE AND LASER LENGTHS TAKING INTO ACCOUNT MODE SHAPE CHANGES A65-29505
- SCOVIL, H. E. D.  
MASER AND LASER PROPERTIES INCLUDING RADIATION FIELD AND MASER MEDIA, NOTING MOLECULAR AMPLIFICATION CENTERS AND ENGINEERING PROBLEMS A65-26935
- SEALER, D. A.  
FORWARD TRAVELING COHERENT ACOUSTIC WAVE AND BACKWARD TRAVELING ELECTROMAGNETIC WAVE PRODUCED IN STIMULATED BRILLOUIN SCATTERING OF INTENSE LASER BEAM A65-32745
- OPTICAL MASER AS POWER SOURCE FOR NARROW BAND ELECTROMAGNETIC RADIATION THROUGH STIMULATED RAMAN SCATTERING - SOLID STATE PHYSICS REPT.-1935-6 N66-10581
- SECREST, G.  
HIGH INTENSITY ULTRAVIOLET RADIATION SOURCE TO PUMP PHOSPHORS AND LASER MATERIALS WITH ABSORPTION BANDS IN PHOSPHOR EMISSION SPECTRUM DDRF-173 N65-14365
- SEDELNIKOV, V. A.  
OUTPUT POWER OF CW LASER MEASURED BY WIRE BOLOMETER IN FORM OF PLANE SINGLE-LAYER SPIRAL AS SENSITIVE ELEMENT A66-20364
- SEDNEY, R.  
CONVENTIONAL FLOW VISUALIZATION USING LASER LIGHT SOURCE AIAA PAPER 66-127 A66-17104
- SEDOV, B. M.  
STATIONARY AND TRANSIENT LIGHT AMPLIFICATION REGIMES IN ACTIVE MEDIA OPERATING ACCORDING TO FOUR-LEVEL SCHEME A65-18455
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM FLUORIDE DOPED WITH SAMARIUM A65-24085
- STATIONARY AND TRANSIENT LIGHT AMPLIFICATION REGIMES IN ACTIVE MEDIA OPERATING ACCORDING TO FOUR-LEVEL SCHEME A65-28084
- SPECTRAL DISTRIBUTION OF STIMULATED RADIATION WITH RESPECT TO AXIAL OSCILLATION MODES FROM CALCIUM FLUORIDE DOPED WITH SAMARIUM A65-34906
- SEDYKH, V. M.  
TWO-FREQUENCY VOLUME RESONATOR WITH INDEPENDENT TUNING WITHIN WIDE FREQUENCY BAND A66-18918
- SEE, B. A.  
STUDY OF PARAMETERS OF HIGH GAIN 2.026 MICRON XENON-HELIUM LASER TO OPTIMIZE POWER OUTPUT AND EFFECT OF TUBE DIAMETER ON SMALL SIGNAL GAIN WRE-PAD-104 N65-28901
- SEEBER, K. W.  
PHENOMENOLOGICAL TREATMENT OF SATURATION EFFECTS IN SOLID STATE LASER AMPLIFIERS A65-18887
- SEED, R. G.  
STORAGE DIODE LASER RESEARCH AD-618297 N65-34108
- SEELIG, M.  
HELIUM-NEON GAS DISCHARGE INTENSIFICATION FOR 6328 A LASER WAVELENGTH, DISCUSSING MEASUREMENT TECHNIQUES, GAIN PARAMETERS AND RESULTS

- A66-18632
- SEGARD, N.**  
PERIODIC VARIATION OF QUALITY FACTOR OF HE- NE  
GAS LASER CAVITY BY VIBRATING QUARTZ-MODULATION OF  
LIGHT BEAM A66-13477
- SEGRE, J. P.**  
TRIMMING MICROCIRCUIT ELEMENTS LIKE EVAPORATED  
THIN-FILM AND SILK-SCREENED CERMET-FILM RESISTORS  
ATTEMPTED WITH CW AND PULSED LASERS A66-14562
- SEHR, R. A.**  
GALLIUM ARSENIDE LASER DIODES FABRICATED BY  
DIFFUSION OF ZINC N65-17442  
QPR-1
- EXTERNAL POWER EFFICIENCY OF GALLIUM ARSENIDE  
LASER DIODES N65-32069  
QPR-2
- METHODS OF JUNCTION FORMATION TO OBTAIN ROOM  
TEMPERATURE GALLIUM ARSENIDE LASER DIODES N65-34184  
QPR-3
- SEIFERT, F.**  
CURRENT DISCHARGE OF HELIUM NEON LASER ON LASER  
ACTION A66-12439
- SELIVANENKO, A. S.**  
SUPERCONDUCTING STATES IN IMPURITY-FREE  
SEMICONDUCTORS CREATED BY LASER ILLUMINATION A65-28492
- SUPERCONDUCTING STATES IN IMPURITY-FREE  
SEMICONDUCTORS CREATED BY LASER ILLUMINATION A66-12091
- SENATSKII, I. V.**  
LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION A65-35875
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION A65-35877
- ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION  
IN NEODYMIUM GLASS LASER A65-36826
- ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION  
IN NEODYMIUM GLASS LASER A66-13431
- LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION A66-18970
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION A66-18972
- SENITZKY, I. R.**  
QUANTUM OPTICS THEOREM ON CLASSICAL SOURCE FOR  
WHICH EFFECT OF DETECTOR AND DISSIPATION MECHANISM  
IS NEGLIGIBLE A66-22967
- SEPTIER, A.**  
HIGH INTENSITY LOW VOLTAGE DISCHARGE RESULTING  
FROM RUBY LASER BEAM FOCUSING ON TITANIUM HYDRIDE  
TARGET A65-24282
- SETTE, D.**  
OPTICAL COHERENT WAVE PROPERTIES SUITABLE FOR LONG  
DISTANCE LASER COMMUNICATIONS AND COMPARED WITH  
RADIO WAVE CHARACTERISTICS A65-20006
- COHERENCE PROPERTIES OF HELIUM-NEON LASER WITH  
SUPERIMPOSED MODES EXAMINED BY INTERFERENCE  
PATTERN A66-10337
- SHACKLETON, J. R.**  
LASER MICROWELDING EVALUATION WITH REGARD TO  
BONDING OF DISSIMILAR ELECTRONIC INTERCONNECTION  
MATERIALS FOR THIN FILM CIRCUITS A65-24352
- LASER TECHNIQUES FOR WELDING POLYTHERMALESE COATED  
MAGNET WIRE TO STAINLESS STEEL AND GOLD PLATED  
NICKEL TERMINALS N66-19615  
NASA-CR-70935
- SHAFFER, D.**  
SPIRAL FRINGES IN INTERFERENCE PATTERN OF  
INTERFEROMETER WITH LASER ILLUMINATION AS  
INDICATION OF DISCONTINUITY IN WAVE FRONT OR  
GENERATING SURFACE A65-33430
- SHALASHOV, V. A.**  
TREATMENT OF STEEL WITH LASER BEAM, OBTAINING  
PRECISION HOLES WITHOUT AFFECTING MICROHARDNESS OF  
METAL A66-24898
- SHAMIR, J.**  
FIRST-ORDER RELATIVITY TEST USING PHASE CHANGE OF  
TWO COHERENT BEAMS A66-19935
- CARNAHAN PROPOSED FIRST ORDER ETHER DRIFT  
EXPERIMENT USING TWO LASERS SHOWN TO BE OF SECOND  
ORDER NATURE, NOTING ROLE OF PHASE SHIFTS A66-21656
- SHANNON, R. R.**  
SPIRAL FRINGES IN INTERFERENCE PATTERN OF  
INTERFEROMETER WITH LASER ILLUMINATION AS  
INDICATION OF DISCONTINUITY IN WAVE FRONT OR  
GENERATING SURFACE A65-33430
- SHARP, J. K.**  
OPTICAL FREQUENCY TRANSLATION TECHNIQUES LEADING  
TO DESIGN OF Y-SHAPED LASER CONFIGURATION N65-15259  
AB-1272-0013
- SHCHEGLOV, V. A.**  
NATURAL MODES OF PLANE AND CYLINDRICAL DIELECTRIC  
RESONATORS IN OPTICAL BAND A65-24810
- SHELEPIN, L. A.**  
PHOTON ROCKET ENGINE USING PLASMA LASER EMISSION  
A65-18375
- SHEPARD, H. K.**  
NONLINEAR ABSORPTION OF LASER RADIATION BY THREE-  
LEVEL ATOMIC SYSTEM N65-28654  
RM-4478-PR
- SHER, A.**  
FEASIBILITY OF LASER OPERATING ON VIBRATIONAL -  
TRANSITIONS - SCHEMES USING FRANCK- CONDON  
PRINCIPLE N65-28168  
VARIAN-314-35
- SHERONOV, A. A.**  
OPTICALLY CONNECTED LASER CONSTRUCTED ON GALLIUM  
ARSENIDE P-N JUNCTION, NOTING COHERENT RADIATION A66-14363
- GALLIUM ARSENIDE P-N JUNCTION LASER DIODE COVERING  
INJECTION CURRENT DISTRIBUTION, DENSITY AND  
EMISSION SPECTRA VARIATION A66-14659
- SHESTOPALOVA, I. P.**  
CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW A66-11190
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW A66-24011
- SHIEH, P.-L.**  
GAIN BANDWIDTH AND STABILITY OF SOLID STATE  
MULTICAVITY MASERS A66-22765
- SHIGEMATSU, T.**  
GAIN SATURATION, LIGHT POWER LEVEL, DISCHARGE  
CURRENT AND METHOD FOR SPECIFYING OUTPUT POWER  
CHARACTERISTICS OF LASER TUBE A65-15326
- SHILDIAEV, V. S.**  
COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM  
OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE  
FABRY- PEROT RESONATOR A65-24088
- COHERENT LIGHT EMISSION BY TWO-COMPONENT QUANTUM  
OSCILLATORS WITH EQUAL ENERGY TRANSITIONS INSIDE  
FABRY- PEROT RESONATORS A65-34909
- SHIMAZU, M.**  
LASER EXCITATION IN FREON AND RARE GAS MIXTURES  
BASED ON DISSOCIATIVE EXCITATION PROCESS AND

- QUENCHING ACTION OF SOME GASES A65-35043
- LASER OSCILLATIONS OF SILICON TETRACHLORIDE,  
SILICON TETRAFLUORIDE AND ETHYL SILICATE IN  
GASEOUS DISCHARGE A66-14973
- SHIMIZU, F.  
OSCILLATION CHARACTERISTICS OF RUBY LASER WITH  
EXTERNAL MIRRORS OF LARGE SPACING A65-33517
- SHIMIZU, T.  
OSCILLATION CHARACTERISTICS OF RUBY LASER WITH  
EXTERNAL MIRRORS OF LARGE SPACING A65-33517
- SHIMODA, K.  
AUTOMATIC FEEDBACK CONTROL FOR LONG-TERM FREQUENCY  
STABILIZATION OF HE- NE LASER AT CENTER  
FREQUENCY OF ATOMIC RESONANCE A65-21620
- PHOTOBLEAT CHARACTERISTICS BETWEEN TWO  
INDEPENDENTLY STABILIZED HE- NE LASERS A65-29117
- OSCILLATION CHARACTERISTICS OF RUBY LASER WITH  
EXTERNAL MIRRORS OF LARGE SPACING A65-33517
- HIGHER ORDER CALCULATION OF LASER OUTPUT, NOTING  
APPROXIMATION METHOD FOR LINEWIDTH PARAMETER AND  
LAMB DIP SHAPE ACCURACY A66-19063
- SHIOYA, H.  
GAIN SATURATION OF RUBY MASER BY NEARBY  
INTERFERING SIGNAL DERIVED FROM MOTION EQUATION OF  
DENSITY MATRIX A66-19933
- SHIPULO, G. P.  
CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT  
ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH  
NEODYMIUM IONS A65-31703
- RUBY LASER RADIATION EFFECT ON FLUORESCENCE AND  
LASER ACTION IN DYSPROSIUM DOPED CALCIUM FLUORIDE  
CRYSTALS A66-10718
- CONTINUOUS OPTICAL QUANTUM GENERATOR OPERATING AT  
ROOM TEMPERATURE ON CALCIUM TUNGSTATE DOPED WITH  
NEODYMIUM IONS A66-19956
- SHIRAKI, H.  
TRAVELING-WAVE TUBE WITH PHOTOELECTRIC CATHODE  
USED AS DEMODULATOR FOR LASER COMMUNICATION A65-14345
- SHIREN, N. S.  
PHONON INTERACTION IN CRYSTALS - TRANSIENTLY  
OPERATED ACOUSTIC MASER, INTERACTION OF PHONONS  
WITH IMPURITIES IN GERMANIUM AND SILICON, AND  
HEAT PULSES IN CRYSTALS QTR-7 N65-27746
- SIGNAL VELOCITY OF MASERS, AND MICROWAVE PHONON  
ATTENUATION AND PULSED HEAT RADIATION IN SINGLE  
CRYSTAL SEMICONDUCTORS REPT.-8 N65-36734
- SHISHKEVISH, C.  
OPTICALLY PUMPED SEMICONDUCTOR LASER IN U.S.S.R.  
N65-30208
- RADIATIVE RECOMBINATION WITH ELECTRON BEAM EXCITED  
CADMIUM TELLURIDE AND GALLIUM SELENIDE N66-12646
- SHOROKHOV, D. A.  
EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS  
BY INCLINING GENERATING SAMPLE WITH RESPECT TO  
INTERFEROMETER AXIS A65-18454
- EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS  
BY INCLINING GENERATING SAMPLE WITH RESPECT TO  
INTERFEROMETER AXIS A65-28083
- SHTEINSHLEIGER, V. B.  
QUANTUM ACTIVE PARAMAGNETIC AMPLIFIER IN FORM OF  
SERIES-COUPLED RESONATORS, NOTING BANDWIDTH  
DEPENDENCE ON RESONATOR NUMBER AND DECOUPLING
- INDEPENDENCE A65-14137
- QUANTUM ACTIVE PARAMAGNETIC AMPLIFIER IN FORM OF  
SERIES-COUPLED RESONATORS, NOTING BANDWIDTH  
DEPENDENCE ON RESONATOR NUMBER AND DECOUPLING  
INDEPENDENCE A65-24012
- TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
8-CM BAND A65-24882
- TRENDS IN MASER AMPLIFIERS, DESCRIBING TYPES AND  
DEVELOPMENT TECHNIQUES A65-31408
- TRAVELING-WAVE QUANTUM PARAMAGNETIC AMPLIFIER  
APPLIED TO RADIO-ASTRONOMICAL INVESTIGATIONS IN  
8-CM BAND A65-36359
- SHULER, K. E.  
CHEMICAL PROCESSES PRODUCING SPECTROSCOPICALLY  
OBSERVABLE POPULATION INVERSIONS IN ATOMIC OR  
MOLECULAR LASERS A65-20066
- SHUVALOV, I. K.  
STIMULATED COMBINATION LIGHT SCATTERING WITHIN AND  
OUTSIDE RESONATOR CAVITY BASED ON LASER  
DEVELOPMENT A65-16627
- SIEGMAN, A. E.  
AXIALLY UNIFORM ENERGY DENSITY IN LASER CAVITY  
OBTAINED, USING BIREFRINGENT SAPPHIRE QUARTER WAVE  
PLATES, RUBY ROD AND TWO MIRRORS A65-16407
- RESONANT MODES OF UNSTABLE OPTICAL RESONATORS AND  
LOSSES A65-21299
- OPTICAL SECOND HARMONIC GENERATION ANGULAR  
VARIATION IN AMMONIUM DIHYDROGEN PHOSPHATE  
GAUSSIAN CW GAS LASER BEAM FOR NONLINEAR  
COEFFICIENT MEASUREMENTS A65-27724
- PUMP POWER DEPENDENCE OF RUBY LASER STARTING AND  
STOPPING TIME PREDICTED VIA RATE EQUATION ANALYSIS  
A66-21309
- UNSTABLE OPTICAL RESONATORS FOR RUBY LASER  
APPLICATIONS ML-1227 N65-33916
- SIGRIANSKII, V. V.  
CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW A66-11190
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW A66-24011
- SILBERG, P. A.  
INTERACTION OF LIGHT PULSE FROM RUBY LASER WITH  
MERCURY SURFACE, OBSERVING MECHANICAL IMPACT  
BELIEVED TO BE RAPID VAPORIZATION PROCESS A66-14373
- LASER PUMPING TECHNIQUES - THETA PINCH ENERGY  
TRANSFER EFFICIENCY IN CONVERSION OF ELECTRIC  
ENERGY TO ELECTROMAGNETIC ENERGY AFOSR-65-2212 N66-15605
- SILFVAST, M. T.  
LASER OSCILLATION IN VISIBLE SPECTRA OF SINGLY  
IONIZED ZINC AND CADMIUM OBTAINED WITH PULSED  
DISCHARGES IN HEATED VAPORS OF THESE METALS MIXED  
WITH NOBLE GASES A65-32747
- LASER OSCILLATION IN VISIBLE REGION FROM PULSED  
COLD CATHODE DISCHARGE IN IONIZED S AND P A65-33379
- SILIN-BEKCHURIN, I. A.  
CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER A66-10704
- CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF  
HF DISCHARGE IN HELIUM-NEON LASER A66-23309

- SILVERBERG, C. G.**  
 PREPARATION OF OPTICALLY HOMOGENEOUS LASER GLASS  
 FREE OF PLATINUM INCLUSIONS BY PLATINUM  
 PASSIVATION OR USING ALL-CERAMIC MELTING SYSTEM  
 SATR-1 N65-22027
- PREPARATION OF PLATINUM-FREE LASER GLASS  
 SATR-2 N66-14672
- SILVERMAN, B. A.**  
 LASER FOG DISDROMETER FOR MEASURING DROPLET SIZE  
 IN FOG A65-17644
- SILVERMAN, D.**  
 SYSTEMS ANALYSIS OF LASERS VS MICROWAVES FOR  
 MARS-TO- EARTH COMMUNICATIONS IN 1970 A65-28248
- SPACE COMMUNICATION REQUIREMENTS USING LASERS AND  
 MICROWAVES IN MANNED MARS FLIGHTS A65-30519  
 AIAA PAPER 65-324
- SIMPSON, J. H.**  
 METASTABLE NITROGEN MOLECULES AS ACTIVE MEDIUM  
 FOR TRANSFORMER LASER PUMPED BY BATTERY OF ND  
 GLASS AUXILIARY LASERS N66-17001  
 GPL-A-31-2
- SIMS, S. D.**  
 SPECTRAL PUMPING EFFICIENCY, SOLARIZATION EFFECT,  
 ENERGY OUTPUT, SPECTROSCOPY, GLASS DAMAGE AND  
 OPTICAL PATH DISTORTIONS IN NEODYMIUM GLASS  
 LASERS N65-24195  
 AD-612964
- EFFECTS OF INTENSE ULTRAVIOLET RADIATION ON GLASS  
 MATERIALS, AND PERFORMANCE CHARACTERISTICS OF  
 GLASS LASERS N66-14533  
 AD-623309
- SINCLAIR, D. C.**  
 LASER OSCILLATION IN PULSED NOBLE-GAS-ION LASER AT  
 NEAR- IR A65-22785
- SINGH, S.**  
 RUBY LASER ROD POSITION ALONG INTERFEROMETER AXIS,  
 DETERMINING PRESENCE OF ADJACENT INTERFEROMETER  
 MODES A65-25874
- SINTSOV, V. N.**  
 LASER APPLICATION IN PHOTOGRAPHY, NOTING  
 INTERFEROMETRIC AND HOLOGRAPHIC TECHNIQUES A66-21333
- SIPES, R. R.**  
 CONCEPTUAL MODEL OF BACKSCATTERED FIELD OF LASERS  
 AND USE FOR ROTATION DETECTION N66-16473  
 GE/EE/65-13
- SIRKIS, M. D.**  
 DIRECT-INDIRECT TRANSITION EFFECT ON HALL EFFECT  
 IN GALLIUM /ARSENIC PHOSPHIDE/ A66-21570
- GROWTH OF GALLIUM ARSENIDE-PHOSPHIDE COMPOUNDS  
 FOR LASER USE N65-27833  
 AFCRL-65-271
- ZINC DIFFUSION IN GALLIUM ARSENIDE-PHOSPHIDE  
 LASERS AND EFFECTS ON SEMICONDUCTOR JUNCTIONS  
 AFCRL-66-18 N66-22611
- SJOBLOM, J. J.**  
 CRYSTAL GROWTH AND PREPARATION OF POTENTIAL LASER  
 MATERIAL CONTAINING RARE EARTH IONS AS DOPANTS A65-17042
- SKLIAROV, IU. A.**  
 OUTPUT POWER OF CW LASER MEASURED BY WIRE  
 BOLOMETER IN FORM OF PLANE SINGLE-LAYER SPIRAL AS  
 SENSITIVE ELEMENT A66-20364
- SKOLNICK, M. L.**  
 OUTPUT OF SINGLE MODE GAS LASER IN AXIAL MAGNETIC  
 FIELD STUDIED FOR INCREASE IN FREQUENCY STABILITY A65-26954
- SKVORTSOV, V. A.**  
 SPECTRAL LINE SHAPE FOR FABRY- PEROT MASER USING  
 VARIOUS OSCILLATION MODES A65-14113
- BEAM MASER EXCITATION PARAMETER CALCULATIONS  
 INCLUDING COLLISION IN BEAM EFFECTS AND COMPARISON  
 WITH MOLECULAR FORMALDEHYDE A65-24825
- SPECTRAL LINE SHAPE FOR FABRY- PEROT MASER USING  
 VARIOUS OSCILLATION MODES A65-24933
- PARAMETER OF EXCITATION OF MOLECULAR BEAM TYPE  
 MASER RESONATOR N65-27253
- SLAMA, L.**  
 NOBLE GAS MOLECULAR SCATTERING OF RUBY LASER LIGHT  
 COMPARED WITH RAYLEIGH THEORY A65-15438
- DENSITY, TEMPERATURE AND SPEED OF EXPANSION OF  
 PLASMA CLOUD PRODUCED BY IMPACT OF RUBY LASER BEAM  
 ON ALUMINUM STRIP A65-29558
- MOLECULAR SCATTERING OF LIGHT USING RUBY LASER  
 SOURCE N65-32985  
 CEA-R-2375
- SLANSKY, S.**  
 MONOGRAPH ON THEORY OF COHERENCE IN OPTICS  
 INCLUDING CONCEPT OF DEGREE IN COHERENCE,  
 COHERENCE IN QUASI-MONOCROMATIC LIGHT AND IN  
 DIFFRACTION PHENOMENA A65-33897
- SLANSKY, Z. I.**  
 GAS EFFECTS PRODUCED BY PULSED LASER BEAM IN  
 BALLISTIC TORSIONAL PENDULUM PHOTOMETER, NOTING  
 DEFLECTION DUE TO PHOTON MOMENTUM EXCHANGE A65-32229
- SLEEPER, A. M.**  
 SECOND HARMONIC LIGHT GENERATED ON REFLECTION OF  
 GIANT-PULSE LASER BEAM FROM SURFACE OF SILVER  
 MIRROR A66-16072
- SLOAN, E. L., III.**  
 LOW FREQUENCY MAGNETIC FIELD SENSOR - PROTON  
 MASER ANTENNA DESIGN CONSTRUCTION AND  
 PERFORMANCE N65-32211  
 RADC-TR-64-567
- SLAKULA, A.**  
 CRYSTAL GROWTH, LATTICE CONSTANT, AND DENSITY OF  
 MAGNESIUM POTASSIUM FLUORIDE AND BARIUM  
 ZIRCONATE N66-14467  
 AD-623511
- SMILEY, V. N.**  
 LASER BEAM AMPLIFICATION BY REFLECTION FROM  
 SCANNING GAS LASER ACTIVE INTERFEROMETER A65-33047
- GAIN AND BANDWIDTH NARROWING IN REGENERATIVE  
 HELIUM-XENON LASER AMPLIFIER A66-12308
- INFRARED SPECTRUM, OPTICAL PROPERTIES, AND  
 FABRICATION OF EIGHT-METER GAS LASER N65-14446  
 NEL-1242
- SMIRNOV, V. S.**  
 INDUCED EMISSION MODES OF TRAVELING WAVE LASER A66-10778
- INDUCED EMISSION MODES OF TRAVELING WAVE LASER A66-22290
- SMIRNOVA, A. D.**  
 FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD  
 OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK  
 SHOCK WAVE IN LASER BEAM A66-10263
- FAST PHOTOIONIZATION AUREOLE DETECTION AND CLOUD  
 OF CONCENTRATED LONG-LIVED IONIZATION FROM SPARK  
 SHOCK WAVE IN LASER BEAM A66-13308
- SMIRNOVA, M. N.**  
 HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE  
 EXCITATION AND GENERATION KINETICS IN RUBY LASER  
 WITH CONCENTRIC CAVITY A65-18460
- HIGH RESOLUTION STREAK CAMERA TO INVESTIGATE MODE  
 EXCITATION AND GENERATION KINETICS IN RUBY LASER  
 WITH CONCENTRIC CAVITY A65-28089



- SMITH, A. W.**  
INTENSITY FLUCTUATIONS MEASURED IN EMISSION FROM  
VARIOUS LASING AND NONLASING MODES OF CONTINUOUS  
WAVE GA AS LASER A65-34687
- SMITH, D. C.**  
MECHANISMS ASSOCIATED WITH ELECTRICAL BREAKDOWN  
AND IONIZATION IN GAS CAUSED BY HIGH INTENSITY  
RUBY OR NEODYMIUM LASER ILLUMINATION  
D-920272-4 N66-11453
- RUBY LASERS USED IN STUDYING PHYSICAL PROCESSES  
LEADING TO IONIZATION OF GASES BY INTENSE  
OPTICAL RADIATION  
UACRL-E920272-6 N66-20600
- SMITH, D. S.**  
SIMPLE SINGLE MODE HELIUM-NEON LASER WHOSE OUTPUT  
IS SUFFICIENT FOR INTERFEROMETRIC METROLOGY  
A65-22621
- ELECTRODELESS EXCITATION OF DISCHARGE IN HELIUM-  
NEON GAS LASER TUBE APPLIED TO VOICE TRANSMISSION  
A66-14924
- SMITH, F. W.**  
TRAVELING WAVE MASER FOR TELSTAR AND RELAY  
SATELLITES, DISCUSSING ELECTRONICS AND SOLID STATE  
PHYSICS PRINCIPLES AND DESIGN A65-16798
- SMITH, G. F.**  
DISPERSION EFFECTS IN LASER AMPLIFIERS  
AFOSR-65-2211 N66-16411
- SMITH, J.**  
MIRROR HOLDER WITH DEFORMABLE HINGES GIVING  
CONSTANT HINGE LINES AT RIGHT ANGLES FOR GASEOUS  
AND SOLID STATE LASERS USE A65-28590
- DEVELOPMENT AND APPLICATION OF IMPROVED MASER  
TECHNIQUES FOR BROADBAND MASER SYSTEM -  
TRAVELING WAVE MASER TECHNIQUES  
RADC-TR-65-148 N65-32203
- SMITH, J. C.**  
SOLID STATE AND MASER TECHNIQUES - BREADBOARD  
EVALUATION, MEASUREMENTS OF LOW-TEMPERATURE  
SEMICONDUCTOR, AND SUPERCONDUCTING THIN FILM  
TUNNELING EFFECTS  
RADC-TDR-64-480 N65-16017
- SOLID-STATE AND TRAVELING-WAVE MASER TECHNIQUES  
RADC-TR-65-30 N65-33397
- BROADBAND TRAVELING WAVE MASER TECHNIQUES AND  
N-TYPE GERMANIUM SEMICONDUCTOR DEVELOPMENT  
RADC-TR-65-366 N66-15720
- SMITH, J. T.**  
CHROMIUM ALIGNMENT IN RUBY BY OPTICALLY PUMPING  
RUBY SAMPLE WITH CIRCULAR POLARIZED RADIATION FROM  
RUBY LASER A65-33418
- SMITH, P. W.**  
SINGLE-MODE SELECTION AND MODE VOLUME ENHANCEMENT  
IN HE- NE GAS LASER WITH INTERNAL LENS  
A65-26820
- TRANSVERSE MODES OF LASER ANALYZED WITH SCANNING  
INTERFEROMETER BY MATCHING RESPECTIVE MODES OF TWO  
DEVICES A65-29531
- STABLE SINGLE-FREQUENCY OUTPUT FROM LASER CAVITY  
OBTAINED BY FILTER METHOD AND RESONANCE  
SUPPRESSION METHOD A66-18356
- SMITH, R. C.**  
REDUCTION OF LOCKING FREQUENCY OF RING LASER BY  
MAKING TWO BEAMS ORTHOGONAL A65-19601
- SMITH, R. G.**  
RUBY LASER ROD POSITION ALONG INTERFEROMETER AXIS,  
DETERMINING PRESENCE OF ADJACENT INTERFEROMETER  
MODES A65-25874
- COHERENT HIGH POWER PULSES FROM OPTICALLY PUMPED  
Y A G- ND LASER BY Q-SWITCHING FROM MIRROR  
ROTATION A65-26003
- CONTINUOUS OPTICAL SECOND-HARMONIC GENERATION  
USING ND/YAG LASER AND CRYSTAL OF SINGLE-DOMAIN  
LITHIUM NIOBATE A66-16378
- SMORCHKOV, V. N.**  
CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL  
RUBY CRYSTALS DUE TO HEATING BY EXCITING LIGHT  
A65-18461
- CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL  
RUBY CRYSTALS DUE TO HEATING BY EXCITING LIGHT  
A65-28090
- ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN  
ENERGY ABSORPTION AND POPULATION INVERSION  
A65-36055
- ENERGY LOSSES IN RUBY LASER DUE TO HEAT EVOLUTION  
DURING OPTICAL PUMPING, NOTING RELATION BETWEEN  
ENERGY ABSORPTION AND POPULATION INVERSION  
A66-15858
- SMOYER, C. B.**  
TRAVELING WAVE OSCILLATIONS IN RUBY LASER  
RESONATOR USING PASSIVE OPTICAL ISOLATOR,  
ELIMINATING FARADAY ROTATOR AND ATTENDANT  
MAGNETIC FIELD A66-11448
- SPECTRAL LINE WIDTH NARROWING OF PULSED TRAVELING  
WAVE RUBY LASER OUTPUT  
AD-610865 N65-22139
- SPECTRAL LINE WIDTH NARROWING IN TRAVELING WAVE  
RUBY LASER CAVITY EMISSION N66-16658
- SMY, P. R.**  
DENSE HIGH-TEMPERATURE HYDROGEN PLASMA PRODUCTION  
BY INTENSE LASER PULSE HEATING OF MAGNETICALLY  
CONTAINED PLASMA A65-29978
- SNITZER, E.**  
YB3- ER3 GLASS THREE LEVEL LASER ACTION  
A65-17208
- LINE NARROWING OF NEODYMIUM GLASS LASER WITH  
REFLECTION A66-17291
- SNYDER, G. L.**  
LASER RANGING EXPERIMENTS PERFORMED WITH BEACON  
EXPLORER B A65-21303
- SOGHOR, V.**  
OSCILLATION SPIKES IN QUASI-CONTINUOUS OPERATION  
OF RUBY LASER AT ROOM TEMPERATURE, NOTING  
THRESHOLD PUMPING ENERGY A66-17532
- SOFFER, B. H.**  
PULSED AND CONTINUOUS WAVE LASER OPERATION OF  
THULIUM ION DOPED ERBIUM OXIDE WHICH PROVIDES  
PUMPING MECHANISM BY MEANS OF ENERGY TRANSFER  
A65-26955
- SOKOLOV, A. K.**  
TIME DEPENDENT VARIATION OF RUBY LASER STIMULATED  
EMISSION INTENSITY A65-19074
- EMISSION SPECTRUM OF RUBY LASER WITH EXTERNAL  
SPHERICAL MIRRORS IN NONDAMPING INTENSITY  
FLUCTUATIONS AND QUASI-STEADY GENERATION  
A65-21041
- TIME DEPENDENCY OF INTENSITY OF STIMULATED  
EMISSION IN RUBY LASER WITH OPTICAL RESONATOR  
CONTAINING ALUMINUM-COATED OPAQUE SPHERICAL  
MIRRORS A65-23014
- DISMOUNTABLE FLASH LAMP FOR LASER, INCLUDING CROSS  
SECTIONAL SCALE DRAWING AND WIRING DIAGRAM  
A66-23296
- SOLIMENE, N.**  
LASER ACTION ON FIVE GREEN LINES AND SIX IR LINES  
CAUSED BY PULSING MANGANESE DISCHARGE OF COLLISION  
LASER IN ATOMIC VAPOR OF NEUTRAL MANGANESE  
A66-16763
- PERTURBED AND PLANE PARALLEL FABRY- PEROT  
RESONATORS, THERMAL FIELDS, QUANTUM OPTICAL

COHERENCE, SPONTANEOUS EMISSION, AND DYNAMICAL  
THEORY OF LASER OSCILLATION  
AFRL-65-270 N65-27088

SOLOMONIAN, A. H.  
PARAMETER DEPENDENCE OF INTERMEDIATE FREQUENCY  
VOLTAGE INDICATED DURING ESTABLISHMENT OF OPTIMUM  
CONDITIONS FOR OPTICAL RECEIVERS AND MERIT OF  
SUBCARRIER MIXING A66-23960

SOMA, A.  
PARAMETRIC DEPENDENCE OF TIME PROFILE, PEAK POWER  
AND NUMBER OF GIANT PULSES OF ROTATING PRISM  
Q-SWITCHED LASERS A65-15103

INTERFERENCE FRINGE VISIBILITY UP TO 120 M OPTICAL  
PATH DIFFERENCE, USING HELIUM-NEON LASER SOURCE  
A65-16766

EMISSION CHARACTERISTICS OF Q-SWITCHED RUBY LASER  
WITH SATURABLE ABSORBER A65-35053

INTENSITY DISTRIBUTION OF FRINGE SYSTEMS USED TO  
VERIFY PHASE INVERSION BETWEEN TWO LOBES OF LASER  
IN TEM-10 MODE A66-17453

SOOY, W. R.  
NATURAL SELECTION OF MODES USING PASSIVE Q-SWITCH  
IN GIANT PULSE RUBY LASER WHICH NARROWS OUTPUT  
SPECTRUM A65-29850

GAIN MEASUREMENTS OF RAMAN AMPLIFIER PUMPED BY  
DIFFUSE RUBY RADIATION A66-16388

SOPER, W. L.  
OPTICAL DISCRIMINATOR SYSTEM TO IDENTIFY INFRARED  
REFLECTING SURFACES FOR USE IN MASER RESEARCH  
HDL-TM-65-41 N66-17361

SOROKIN, V. N.  
GAS LASER OUTPUT AND THRESHOLD IN POPULATION  
INVERSION FROM PHOTODISSOCIATION OF METHYL IODIDE  
AND FLUORO IODO METHYLIDYNE A66-16771

SOSKIN, M. S.  
RADIATION FLUCTUATIONS IN LASER PULSE REGIME,  
DISCUSSING ERRORS ARISING IN COMPARING BASIC WITH  
SECONDARY EMISSION A65-14617

TIME CHARACTERISTICS IN GENERATION OF GIANT LASER  
PULSE STUDIED BY CIRCUIT WITH PRISMATIC SHUTTERS  
A66-13889

DISPERSION RESONATOR PERFORMANCE IN RUBY LASER,  
SHOWING GENERATION OF R SUB 1 AND R SUB 2 LINES  
A66-16346

THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-19669

THRESHOLD PARAMETERS AND SPECTRAL COMPOSITION OF  
RADIATION OF NEODYMIUM-GLASS LASER IN DISPERSION  
RESONATOR A66-21836

DISPERSION RESONATOR PERFORMANCE IN RUBY LASER,  
SHOWING GENERATION OF R SUB 1 AND R SUB 2 LINES  
A66-22345

SOTSII, B. A.  
STIMULATED EMISSION OF ELECTROMAGNETIC WAVES FROM  
CIRCULAR CYLINDER AND SPHERE A65-17219

CIRCULAR DIELECTRIC RESONATOR UNDER CRITICAL  
OPERATING CONDITIONS IN ANALYSIS OF PERFORMANCE  
AND ENERGY LOSS A65-36011

SOULE, M.  
FRACTURES IN NEODYMIUM-DOPED ALKALINE SILICATES  
AND BOROSILICATES PRODUCED BY LASER BEAM  
A66-14174

SOUTIF, M.  
MASER PRINCIPLES, PRACTICAL DESIGN AND CURRENT  
APPLICATION A65-30377

SPADIN, P.  
REFLECTED RADIATION OF Q-SPOILED RUBY LASER FROM  
EXPLORER XXII A65-21306

SPECHT, W. A., JR.  
OBLATE SPHERICAL CAVITY MODE APPROACH TO MODE  
STRUCTURE OF LASER RESONATOR, USING VECTOR WAVE  
EQUATION A65-22932

SPENCER, E. G.  
MICROWAVE PROPERTIES PARTICULARLY LINEWIDTH AND  
MAGNETIC ANISOTROPY IN CALCIUM-VANADIUM BISMUTH  
GARNET, NOTING TWM ISOLATOR A65-24964

SPIILHAUS, A. F., JR.  
LIGHT SCATTERING IN SEA WATER - FORWARD SCATTERING  
OF LASER BEAM IN SEA WATER AND FORTRAN PROGRAM  
SCATTERING CALCULATIONS  
AD-610126 N65-23316

SPIZHOVA, N. I.  
EFFECTS OF RESONATOR LENGTH AND MIRROR  
TRANSPARENCY AND ALIGNMENT UPON DYNAMIC AND STATIC  
CHARACTERISTICS OF RUBY LASER WITH MODULATED  
Q-FACTOR A65-35786

STAAS, P. C., JR.  
MOVING SURFACE VELOCITY MEASUREMENT USING LASER  
RADIATION  
GE/EE/64-18 N65-17373

STAATS, P. A.  
INEXPENSIVE SIMPLIFIED CONSTRUCTION OF DC POWERED  
HELIUM NEON LASER WITH 6328 ANGSTROM OUTPUT  
A65-19849

STAERK, H.  
NANOSECOND HEATING OF AQUEOUS SYSTEMS BY  
Q-SWITCHING ROTATING PRISM RUBY LASER  
A65-15788

LASER POWER DENSITY MEASURED WITH REDUCED  
ABSORPTION OF LIGHT BY METHYLENE BLUE, USING HE-  
NE- CW LASER A65-31455

STAFFORD, J.  
HIGH INTENSITY ULTRAVIOLET RADIATION SOURCE TO  
PUMP PHOSPHORS AND LASER MATERIALS WITH  
ABSORPTION BANDS IN PHOSPHOR EMISSION SPECTRUM  
DDR-173 N65-14365

STAHL, J.  
EFFECT OF LASER IRRADIATION ON INNER EAR IN  
PIGEONS A66-80961

STAHMANN, J. R.  
LASER PRODUCTION OF HARD ULTRAVIOLET LIGHT FOR  
STUDYING LIGHTNING AND ATMOSPHERIC PROPAGATION  
LET-417 N65-14074

STANBERG, R. C.  
LASER SIMULATED NUCLEATION IN BUBBLE CHAMBER,  
COMPARING SENSITIVITY WITH RADIOACTIVELY  
STIMULATED NUCLEATION A66-21583

STANKOWSKI, J.  
ELECTRON PARAMAGNETIC RESONANCE THEORETICAL  
ASPECTS AND APPLICATION TO ATOMIC NUCLEI  
POLARIZATION, INCREASED SPECTROMETER RESOLUTION  
AND SOLID STATE MASERS A65-32773

STATZ, H.  
LASER OUTPUT SPIKING ELIMINATION USING KERR CELL  
CONTROLLED BY FEEDBACK CIRCUIT A65-24954

LASER MODE DEFORMATION FROM NONUNIFORMITIES IN  
GAIN SATURATION A65-27328

TRANSITION PROBABILITIES FOR AR II LASER LINES  
COMPARED WITH PREVIOUS THEORETICAL AND  
EXPERIMENTAL DATA A65-29799

PHASE-LOCKING EFFECT AND PHASE SUM OF LF AND HF  
OSCILLATING MODES IN LASER A66-18413

STAVIS, G.  
RELATIVITY VELOCITY SENSING TECHNIQUE FOR MOVING  
VEHICLE BY LASER LIGHT BACKSCATTERED FROM SURFACE  
A65-14934

DIFFRACTION VELOCIMETER DETECTING AND MEASURING  
TRANSVERSE MOVEMENT OF SURFACE BY SENSING LIGHT  
BACKSCATTERED BY IT WHEN LASER ILLUMINATED

- A66-18333  
OPTICAL DIFFRACTION VELOCIMETER, USING  
BACKSCATTERED LASER LIGHT TO MEASURE RELATIVE  
VELOCITY BETWEEN LIGHT SOURCE AND SURFACE  
A66-22958
- STEDDINGS, R. F.  
CHARGE TRANSFER AS LASER PUMPING TECHNIQUE  
A65-20063
- STEELE, E. L.  
RUBY LASER AMPLIFIER ENERGY INPUT-OUTPUT  
MATHEMATICAL ANALYSIS AND EXPERIMENTAL  
VERIFICATION  
A65-17648
- MODEL DESCRIPTION AND MATHEMATICAL FORMULATION FOR  
SPIKE PULSING PHENOMENON OBSERVED IN OPTICALLY  
PUMPED THREE-LEVEL LASERS  
A65-27607
- FUSED SILICA OUTPUT COUPLING COMPONENT FOR LASER  
SYSTEM, USING FRUSTRATED TOTAL INTERNAL REFLECTION  
CONFIGURATION  
A66-17287
- MODEL FOR LASER AMPLIFIER IN WHICH EXCITED  
ELECTRON DENSITY IN HOST LASER MATERIAL IS  
STIMULATED TO PRODUCE OPTICAL ENERGY  
N65-24343
- STEIN, R. A.  
LASER GIANT PULSING USING SATURABLE ABSORBER  
INSIDE CAVITY AS FAST SWITCH  
A65-24960
- STEIN, R. S.  
CONTINUOUS WAVE GAS LASER AND HIGH SPEED MOTION  
PICTURE CAMERA FOR DETECTION OF NEARLY  
CONTINUOUS SET OF LIGHT SCATTERING PHOTOGRAPHS  
FROM POLYETHYLENE POLYMER SAMPLE  
ONR-TR-77  
N65-25399
- STEINBERG, G. M.  
CAUSES OF LASER DAMAGE TO OPTICAL COMPONENTS  
PE-TR-7735  
N65-14185
- STEPANOV, B. I.  
RUBY LASER NOISE RADIATION CONSISTING OF INCREASED  
LUMINESCENCE AND Laterally DISPERSED GENERATION  
DETERMINED FROM ENERGY LEVEL POPULATIONS  
A65-35863
- RADIATION SCATTERING FACTOR DETERMINATION FOR RUBY  
LASER  
A65-36013
- RUBY LASER NOISE RADIATION CONSISTING OF INCREASED  
LUMINESCENCE AND Laterally DISPERSED GENERATION  
DETERMINED FROM ENERGY LEVEL POPULATIONS  
A66-16628
- STEPANOV, D. P.  
HELIUM-NEON LASER MULTIBEAM GENERATION IN GAS  
DISCHARGE TUBE, USING SPHERICAL MIRRORS AND  
TAPERED PLATES  
A65-24824
- MULTIBEAM GENERATION OF GASEOUS HELIUM-NEON LASER  
N65-27252
- STEPHANI, D.  
XENON FLASH TUBE FIRING SYSTEM FOR LASERS  
BNL-9257  
N66-20553
- STEPHANY, J. F.  
LASER MODULATION AT ATOMIC LEVEL - POPULATION  
INVERSION AND ESTIMATE OF ZEEMAN SPLITTING  
NASA-CR-60572  
N65-16320
- RUBY LASER MODULATION AT ATOMIC LEVEL - FREQUENCY  
SHIFT MEASUREMENT OF LASER EMISSION UNDER  
INHOMOGENEOUS MAGNETIC FIELD BY SPECTROSCOPY  
NASA-CR-57464  
N65-19863
- LASER MODULATION AT ATOMIC LEVEL - YTTRIUM-  
ALUMINUM GARNET EMISSION AND LASER EMISSION  
SHIFT WITH HOMOGENEOUS PULSED MAGNETIC FIELD  
NASA-CR-57823  
N65-21308
- MEASUREMENT OF TEMPERATURE DEPENDENCE OF ENERGY  
LEVELS INVOLVED IN LASER EMISSION  
NASA-CR-64436  
N65-32191
- STEPHENS, R. B.  
WAVELENGTH OF 3S2-2P4 TRANSITION OF NEON MEASURED,  
USING HELIUM-NEON LASER  
A66-16387
- ABSOLUTE WAVELENGTH STABILITY OF HELIUM-NEON LASER  
MEASURED BY DIRECT INTERFEROMETRIC COMPARISON WITH  
HG 198 STANDARD LAMP  
A66-22868
- STEPIN, L. D.  
QUANTUM RF PHYSICS TEXT COVERING MAGNETIC  
RESONANCE THEORY, ELECTRON PARAMAGNETIC RESONANCE,  
NUCLEAR MAGNETIC RESONANCES, TWO- AND THREE-LEVEL  
MASERS, RF GAS SPECTROSCOPY AND AMMONIA  
OSCILLATOR  
A66-10954
- STERN, F.  
SWITCHING CHARACTERISTICS OF NEGATIVE RESISTANCE  
DIODE DETERMINATION - INJECTION LASER  
REPT.-7  
N65-27203
- STERN, W. A.  
MAGNETICALLY UNSHIELDED OPTICALLY PUMPED 87 Rb  
MASER OSCILLATOR  
A65-16673
- SERRETT, J. R.  
INTERFEROMETER USING SMALL DIFFRACTION GRATING AND  
GAS LASER LIGHT SOURCE IN SCHLIEREN SYSTEM FOR  
FLUID MECHANICS RESEARCH  
A65-25332
- SETSEMKO, B. V.  
RADIATION FLUCTUATIONS IN LASER PULSE REGIME,  
DISCUSSING ERRORS ARISING IN COMPARING BASIC WITH  
SECONDARY EMISSION  
A65-14617
- SETSEMER, D. A.  
LASER PULSE-SHAPING AND MODE-LOCKING WITH  
TRAVELING AND STATIONARY ACOUSTIC WAVES IN ARGON  
LASER  
A65-31763
- STICKLEY, C. M.  
THERMAL DISTORTION, EXPANSION AND SCATTERING IN  
RUBY AND GLASS LASER RODS DURING AND AFTER PUMP  
FLASH  
A65-35068
- PROPERTIES OF LASERS AND APPLICATION TO  
SCIENTIFIC INSTRUMENTATION, COMMUNICATIONS,  
BIOLOGY, PRECISION MEASUREMENTS, METAL WORKING,  
AND MISCELLANEOUS AREAS  
AFCL-64-914  
N65-16002
- STILLMAN, G.  
ZINC DIFFUSION IN GALLIUM ARSENIDE-PHOSPHIDE  
LASERS AND EFFECTS ON SEMICONDUCTOR JUNCTIONS  
AFCL-66-18  
N66-22611
- STILLMAN, G. E.  
DIRECT-INDIRECT TRANSITION EFFECT ON HALL EFFECT  
IN GALLIUM /ARSENIC PHOSPHIDE/  
A66-21570
- STIMLER, M.  
ELECTRON BEAM PENETRATION IN LASER CRYSTALS FROM  
DATA OF KING AND EHRENBURG  
A65-22627
- GAS EFFECTS PRODUCED BY PULSED LASER BEAM IN  
BALLISTIC TORSIONAL PENDULUM PHOTOMETER, NOTING  
DEFLECTION DUE TO PHOTON MOMENTUM EXCHANGE  
A65-32229
- LASER ACTION BY ELECTRON BEAM PUMPING - LITERATURE  
SURVEY  
NOLTR-65-95  
N65-33401
- STOCKER, T. L.  
RUBY LASER POWER DEPENDENCE ON FREQUENCY SPLITTING  
OF TWO COMPONENTS OF R1 DOUBLET AT 77 DEGREES K  
A65-17654
- STOCKMAN, D. L.  
STIMULATED EMISSION IN FLUORESCENT ORGANIC  
MOLECULES  
N65-15504
- PRODUCTION OF STIMULATED EMISSION IN BLUE-GREEN  
REGION IN ORGANIC DOPANT AND HOST SYSTEM -  
AROMATIC ORGANIC LASER DEVELOPMENT  
AD-613295  
N65-25734
- FLUORESCENT ORGANIC LASER DEVELOPMENT - THETA  
PINCH ARGON LAMP MEASUREMENTS  
CR-7  
N65-25966

- STOICHEFF, B. P.**  
BRILLOUIN SCATTERING IN LIQUIDS EXCITED BY HE- NE  
MASER AND OBSERVED BY FABRY- PEROT  
INTERFEROMETER, NOTING ACOUSTIC WAVE VELOCITY AND  
LINE BROADENING A65-15699
- ANGULAR DEPENDENCE OBSERVATIONS, ABSORPTION  
MEASUREMENTS, AND HIGH INTENSITY GAS LASER  
CONSTRUCTION IN STIMULATED RAMAN EMISSION AND  
ABSORPTION SPECTROSCOPY STUDY N66-23584  
AD-626747
- STOILOV, IU. IU.**  
TIME PARAMETERS OF POWERFUL LASER MEASURED WITH  
GA AS PHOTODIODE, NOTING TIME CONSTANT AND TIME  
RESOLUTION OF PHOTODIODE A65-34552
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION A65-35877
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION A66-18972
- STONE, H. A. G.**  
HAZARDS, EFFECT, SAFETY AND PRECAUTION FOR  
PREVENTION OF PHYSICAL INJURIES FROM LASER  
RADIATION A66-13694
- STONG, G. E.**  
SPECTRAL PUMPING EFFICIENCY, SOLARIZATION EFFECT,  
ENERGY OUTPUT, SPECTROSCOPY, GLASS DAMAGE AND  
OPTICAL PATH DISTORTIONS IN NEODYMIUM GLASS  
LASERS N65-24195  
AD-612964
- EFFECTS OF INTENSE ULTRAVIOLET RADIATION ON GLASS  
MATERIALS, AND PERFORMANCE CHARACTERISTICS OF  
GLASS LASERS N66-14533  
AD-623309
- STRAKHOVSKII, G. M.**  
PULSED INDUCED EMISSION IN HYDROGEN BEAM LASER FOR  
CASE OF TWO RELAXATION TIMES, DETERMINING  
POLARIZATION ONLY BY NUMBER OF ACTIVE PARTICLES IN  
RESONATOR A66-24884
- STRASSER, F. F.**  
EFFECT OF RUBY LASER ENERGY ON GAMMA RADIATED  
HUMAN ADENOCARCINOMA CELLS N66-11874  
SAM-TR-65-41
- STRAUB, H. W.**  
DETECTOR AND SOURCE APERATURE DIMENSIONAL CRITERIA  
FOR MAINTAINING LONG RANGE LASER BEAM COHERENCE IN  
TURBULENT AIR A65-28016
- STRAUB, W. D.**  
CURRENT-VOLTAGE CHARACTERISTICS OF CW X-BAND  
GA AS MICROWAVE GUNN GENERATOR A66-23029
- STRAUBEL, H.**  
LASER-BEAM SCATTERING BY INDIVIDUALLY INTRODUCED  
CHARGED POLYSTYRENE SPHERICAL PARTICLES AND  
DROPLETS OF NAPHTHALENE AND WATER IN COMBINATION A66-17473
- STRAUS, T. M.**  
LASER COMMUNICATION SYSTEMS STUDY N65-17940  
FR-64-19-301
- COHERENT LIGHT COMMUNICATION SYSTEM FOR ATMOSPHERE  
CONDITION EFFECTS ON FREQUENCY MODULATED LASER  
BEAM N66-21774  
FR-66-14-37
- STROKE, G. W.**  
THREE-MIRROR CORNER-CUBE INTERFEROMETER SYSTEM  
WITH ROTATION INSENSITIVITY TO PRODUCE HIGH  
CONTRAST LASER FRINGES A65-18217
- LENSLESS PHOTOGRAPHY USING LASERS AND HOLOGRAM/  
INTERFERENCE PATTERNS BETWEEN REFERENCE WAVE AND  
WAVES SCATTERED BY RECORDED OBJECT/PRODUCING  
THREE-DIMENSIONAL IMAGES A65-27196
- TWO-BEAM INTERFEROMETRY BY WAVEFRONT
- RECONSTRUCTION FROM HOLOGRAM RECORDED WITH  
COHERENT BACKGROUND SUCCESSIVELY INTERFERE IN SAME  
LATENT IMAGE A66-23204
- STROZYK, J. W.**  
LASER EXCITATION IN QUARTZ OF ELASTIC MODES OF  
THICK PLATE, SUGGESTING ENERGY COUPLING MECHANISMS A66-12423
- STUCHEBNIKOV, V. M.**  
GALLIUM ARSENIDE LUMINESCENT DIODES WITH  
TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION  
AT HIGH DENSITY CURRENT A65-36787
- GALLIUM ARSENIDE LUMINESCENT DIODES WITH  
TRIANGULAR RESONATOR PRODUCING COHERENT EMISSION  
AT HIGH DENSITY CURRENT A66-19195
- SUBRAMANIAN, M.**  
DIRECT CURRENT POLARIZATION IN NONLINEAR  
DIELECTRIC MEDIUM AT OPTICAL FREQUENCY N65-22518  
TR-EE-64-5
- TWO TYPES OF NONLINEAR INTERACTION OF INTENSE  
LASER BEAM WITH DIELECTRIC MEDIUM - NONLINEAR  
DC POLARIZATION AND SUBHARMONICS GENERATION AT  
OPTICAL FREQUENCIES N65-33899  
AD-618473
- SUCHKOV, A. F.**  
DERIVATION OF TWO EQUATIONS FOR ELECTROMAGNETIC  
FIELD AND POPULATION INVERSION IN SOLID STATE  
LASER A66-16773
- SUCOV, E. W.**  
LIGHT INTENSITY DISTRIBUTION INSIDE CYLINDRICAL  
REFLECTING CAVITY USING RUBY LASER ROD AND  
ANALYSIS OF INTERDEPENDENCE OF THRESHOLD, FILAMENT  
POSITION AND EFFICIENCY A65-22624
- LOW ANGLE SCATTERING AND INTERFEROGRAPHIC  
MEASUREMENTS USED IN EVALUATING RUBY LASER RODS A65-33416
- SUDARSHAN, E. C. G.**  
RELATION BETWEEN QUANTUM AND SEMICLASSICAL  
DESCRIPTION OF OPTICAL COHERENCE, CONSIDERING  
DISTRIBUTION FUNCTION A65-21379
- SUDZILOVSKII, V. IU.**  
LOCAL LASER HEATING OF CATHODE FOR ELECTRON  
EXTRACTION FROM PLASMOID A66-16149
- SUGAYA, K.**  
HE- NE GAS LASER APPLICATION TO SCHLIEREN  
PHOTOGRAPHY AND MACH- ZEHNDER INTERFEROMETRY IN  
AERODYNAMIC TESTING A65-22501
- NEON-HELIUM GAS LASER APPLICATION TO SCHLIEREN  
PHOTOGRAPHY AND MACH- ZEHNDER INTERFEROMETRY  
FOR USE IN AERODYNAMIC TESTING N65-21372
- SUJAK, B.**  
THERMOSTIMULATED INDUCED ELECTRON EMISSION FROM  
SAMPLES CUT FROM LASER RUBY CRYSTALS DETECTED WITH  
OPEN POINT COUNTER A66-18609
- SUKHODREV, N. K.**  
SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-14131
- SPARK DISCHARGE OBSERVATIONS DURING FOCUSING OF  
PULSED RUBY LASER OUTPUT A65-24951
- SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER  
RADIATION, DETERMINING TEMPERATURE OF PLASMA  
PRODUCED NEAR FOCUS A65-31705
- SPARK DISCHARGE IN AIR INDUCED BY FOCUSING LASER  
RADIATION, DETERMINING TEMPERATURE OF PLASMA  
PRODUCED NEAR FOCUS A66-19959
- SUKHORUKOV, A. P.**  
CONSISTENT THEORY OF NONLINEAR OPTICAL EFFECTS IN  
BOUNDED LIGHT BEAMS BY EXTENDING PARABOLIC  
EQUATIONS TO NONLINEAR PROBLEMS A66-24888

SULLIVAN, J. J.  
PINCH METHODS OF GAS DISCHARGE AS LIGHT SOURCE FOR  
OPTICAL PUMPING OF VARIOUS LASER MATERIALS  
N65-22742

SUSCHINSKII, N. M.  
STIMULATED COMBINATION LIGHT SCATTERING WITHIN AND  
OUTSIDE RESONATOR CAVITY BASED ON LASER  
DEVELOPMENT  
A65-16627

SUTTON, P. M.  
ATMOSPHERIC TURBULENCE EFFECT ON OPERATION OF  
DUAL-POLARIZATION FM LASER COMMUNICATION SYSTEM  
A65-33377

SUZAKI, Y.  
LASER EXCITATION IN FREON AND RARE GAS MIXTURES  
BASED ON DISSOCIATIVE EXCITATION PROCESS AND  
QUENCHING ACTION OF SOME GASES  
A65-35043

LASER OSCILLATIONS OF SILICON TETRACHLORIDE,  
SILICON TETRAFLUORIDE AND ETHYL SILICATE IN  
GASEOUS DISCHARGE  
A66-14973

SUZUKI, C. K.  
INJECTION DIODE LASER FROM DEGENERATED GALLIUM  
ARSENIDE WITH NEODYMIUM DOPED LAYER EMITTING AT  
8700 ANGSTROMS  
A65-15995

SUZUKI, M.  
TIME RESOLVED SPECTROSCOPY OF MERCURY-HELIUM  
DISCHARGE AND 6150 ANGSTROM LASER OSCILLATION,  
EXAMINING METASTABLE ATOM STATE  
A65-33518

RELATION BETWEEN 600 ANGSTROM EMISSION BAND OF  
HELIUM MOLECULE AND IMPRISONMENT OF NEON RESONANCE  
LINES MEASURED TO SHOW EFFECT ON HELIUM-NEON LASER  
OPERATION  
A65-34662

SUZUKI, T.  
FRAUNHOFER PATTERN OF LASER LIGHT TRANSMITTED  
THROUGH OPTICAL FIBER, NOTING SPATIAL FREQUENCY OF  
INTERFERENCE FRINGES BETWEEN LIGHT WAVES  
A66-14972

SVELTO, O.  
E-LEVEL POPULATION IN RUBY ROD AS FUNCTION OF PUMP  
ENERGY EMITTED BY FLASH TUBE  
A65-28013

RUBY LASER OUTPUT EXHIBITING REGULAR SPIKES  
A66-10324

SPIKING BEHAVIOR OF MULTIMODE RUBY LASER IN  
SPHERICAL RESONATOR, INTERPRETING NEAR-FIELD  
PATTERNS, FREQUENCY SPECTRUM, ETC  
A66-21311

SVERGUN, V. I.  
SELF-PULSED MODULATION MODE STABILIZATION OF TWO-  
LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK  
A65-14144

SELF-PULSED MODULATION MODE STABILIZATION OF TWO-  
LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE  
FEEDBACK  
A65-24019

SVIDZINSKIY, K. K.  
MASER DEVELOPMENT FROM INVERSIONAL TRANSITIONS IN  
HEAVY AMMONIA BEAM  
FTD-MT-64-330  
N65-36869

SVIRIDENKOV, E. A.  
DESTRUCTIVE AND LUMINESCENCE EFFECTS OF FOCUSED  
RUBY LASER BEAM ON RUBY  
A66-10265

DESTRUCTIVE AND LUMINESCENCE EFFECTS OF FOCUSED  
RUBY LASER BEAM ON RUBY  
A66-13310

SWEENEY, W. E.  
RUBY LASER CRYSTALS GROWN BY FLAME-FUSION, FLUX  
AND CZOCHRALSKI METHOD EXAMINED FOR PERFECTION BY  
X-RAY TOPOGRAPHY AND DOUBLE-CRYSTAL ROCKING  
CURVES  
A66-13744

SWENDSEN, R. H.  
HIGH SENSITIVITY FAST-RESPONSE LASER DETECTION  
SYSTEM, DESCRIBING MICROWAVE RESPONSE  
PHOTOELECTRIC DETECTOR WITH AMPLIFICATION AND

MIXING FUNCTIONS  
A66-22046

SWIDERSKI, J.  
HOMOGENEITY AND DIFFUSION LENGTH OF MINORITY  
CARRIERS IN SEMICONDUCTORS MEASURED, USING LASER  
BEAM  
A65-33809

SWINSON, W. F.  
GASEOUS AND RUBY LASERS AS LIGHT SOURCES FOR  
PHOTOELASTICITY  
T&AM-276  
N65-29794

SNOPE, C. H.  
DETERMINATION OF ATTENUATING FILTERS REQUIRED FOR  
EYE PROTECTION AGAINST LASER RADIATION  
A65-22614

SYCHUGOV, V. A.  
TRANSITION PROCESSES OF OSCILLATION AMPLITUDE  
FORMATION IN RF THREE-LEVEL MASERS  
A65-15460

TRANSITION PROCESSES OF OSCILLATION AMPLITUDE  
FORMATION IN RF THREE-LEVEL MASERS  
A65-28556

SZABO, A.  
LASER GIANT PULSING USING SATURABLE ABSORBER  
INSIDE CAVITY AS FAST SWITCH  
A65-24960

GROUND STATE ESR SATURATION EFFECT ON RUBY LASER  
OUTPUT FREQUENCY AT CRYOGENIC TEMPERATURE  
A66-16753

## T

TAKAHASHI, K.  
OBSERVATIONS OF RADIO SOURCES AT 9.4 GC WITH 2.2  
FOOT FAN BEAM OF 16-ELEMENT INTERFEROMETER AND  
MASER AMPLIFIER  
A65-28335

TAKAHASHI, T.  
GAIN SATURATION, LIGHT POWER LEVEL, DISCHARGE  
CURRENT AND METHOD FOR SPECIFYING OUTPUT POWER  
CHARACTERISTICS OF LASER TUBE  
A65-15326

TAKATSUJI, M.  
OPTICAL MIXING OF NITROBENZENE RAMAN RUBY LASER  
LIGHT IN ADP AND OTHER NONLINEAR DIELECTRIC MEDIA  
A65-15951

TAKEMOTO, S.  
PULSED RUBY LASER OUTPUT MEASUREMENT BY OPTICAL  
BOLOMETER  
A65-18017

TAKUMA, H.  
STIMULATED BRILLOUIN RADIATION IN OFF-AXIS RUBY  
LASER RESONATOR USING CARBON DISULFIDE CELL,  
EXAMINING OUTPUT SPECTRUM  
A65-16811

STIMULATED RAMAN EFFECT OF BENZENE USING RUBY  
LASER, EXAMINING OUTPUT SPECTRUM, THRESHOLD POWER  
AND EFFICIENCY AT STOKES LINES  
A65-19598

TALBERT, M. W.  
GREEN LASER LIGHT TRANSMISSION THROUGH WATER  
NOLTR-64-179  
N65-20605

TAMAKA, M.  
OBSERVATIONS OF RADIO SOURCES AT 9.4 GC WITH 2.2  
FOOT FAN BEAM OF 16-ELEMENT INTERFEROMETER AND  
MASER AMPLIFIER  
A65-28335

TANG, C.  
SPECTRAL AND TRANSIENT CHARACTERISTICS OF SOLID  
STATE AND SEMICONDUCTOR LASERS, AND NONLINEAR  
INTERACTION OF COHERENT LIGHTWAVES DUE TO RAMAN  
EFFECT  
S-702  
N65-21558

TANG, C. L.  
LASER OUTPUT SPIKING ELIMINATION USING KERR CELL  
CONTROLLED BY FEEDBACK CIRCUIT  
A65-24954

LASER MODE DEFORMATION FROM NONUNIFORMITIES IN  
GAIN SATURATION  
A65-27328

TRANSITION PROBABILITIES FOR AR II LASER LINES

- COMPARED WITH PREVIOUS THEORETICAL AND  
EXPERIMENTAL DATA A65-29799
- PHASE-LOCKING EFFECT AND PHASE SUM OF LF AND HF  
OSCILLATING MODES IN LASER A66-18413
- TANG, H.-L.**  
INFLUENCE OF RESONANT CAVITY, XENON LIGHT, AND  
OTHER PARAMETERS ON RUBY LASER EMISSION ENERGY  
OUTPUT  
FTD-TT-64-1339/1&2&3&4 N66-11522
- TANNENWALD, P. E.**  
LASER, MATERIALS, AND SOLID STATE RESEARCH, BAND  
STRUCTURE AND SOLIDS SPECTROGRAPHY, AND  
MAGNETISM AND RESONANCE  
ESD-TDR-64-349 N65-19816
- TANNER, L. H.**  
ADVANTAGES OF GAS LASERS AS LIGHT SOURCES IN  
AERODYNAMIC RESEARCH INTERFEROMETERS A66-16944
- TARASOV, IU. A.**  
EMISSION SPECTRUM OF RUBY MASER CALCULATED, USING  
DYNAMICS OF TWO-LEVEL SYSTEMS A66-16541
- TARG, R.**  
GENERATION OF SINGLE FREQUENCY LIGHT USING FM  
LASER A65-16670
- LASER OSCILLATION WHEREIN LASER MODES OSCILLATE  
WITH APPROXIMATELY FM PHASES THEREBY COMPRISING  
SIDE BANDS OF FM LIGHT SIGNAL A65-21876
- SUPERMODE LASER AS SINGLE-FREQUENCY GENERATION  
SYSTEM CONSISTING OF FM LASER WITH SYNCHRONOUS  
PHASE MODULATOR AT OUTPUT A65-29267
- CONTROLLING FM AND SUPERMODE LASER OUTPUT  
FREQUENCIES BY THRESHOLD CONTROL AND  
INTERFEROMETRIC CONTROL A65-36842
- AUTOMATIC FREQUENCY CONTROL OF LASER LOCAL  
OSCILLATOR FOR HETERODYNE DETECTION OF LASER  
SIGNAL AND USE OF 2.5 GC FREQUENCY OFFSET TO  
PERMIT RETRIEVAL OF MICROWAVE DATA A66-14908
- OPTICAL HETERODYNE DETECTION OF MICROWAVE  
MODULATED LIGHT USING TWO SEPARATE LASERS  
EDL-H779 N65-16777
- PROPERTIES OF FREQUENCY MODULATION AND SUPER MODE  
LASER IER-1 N66-10766
- EXPERIMENTAL AND THEORETICAL PROGRAM TO DETERMINE  
FUNDAMENTAL PROPERTIES OF FREQUENCY MODULATION  
AND SUPER-MODE LASERS IER-2 N66-21405
- TATARONIS, R.**  
EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASERS S-705 N65-15980
- EXCITATION MECHANISMS IN XENON AND HELIUM-XENON  
GAS LASER, XENON LIFETIMES, AND THEORY OF  
DIFFUSION CONTROLLED GLOW DISCHARGE S-669 N65-28779
- TAUBKIN, I. I.**  
CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW A66-11190
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION  
LASER COOLED BY HELIUM GAS FLOW A66-24011
- TAUSENDFREUND, W.**  
LIGHT DIFFRACTION BY GRATING DUE TO FARADAY AND  
KERR EFFECT IN ELECTROMAGNETIC FIELD OF LASER  
BEAM A65-26582
- TAYLOR, C. A.**  
CONTINUOUS OUTPUT GAS-PHASE LASERS AS SMALL  
BANDWIDTH SOURCES OF LIGHT FOR OPTICAL  
DIFFRACTOMETERS A65-22206
- TAYLOR, C. E.**  
GASEOUS AND RUBY LASERS AS LIGHT SOURCES FOR  
PHOTOELASTICITY TEAM-276 N65-29794
- DYNAMIC STRESS CONCENTRATION USING PHOTOELASTICITY  
AND RUBY LASER LIGHT SOURCE TEAM-285 N66-20850
- TAYLOR, F. J. D.**  
FACILITIES AND EQUIPMENT AT GOONHILLY DOWNS  
SATELLITE SYSTEM GROUND STATION - STEERABLE  
ANTENNA, COMPUTING AND DATA TRANSMISSION, AND  
HELIUM SYSTEM FOR MASER INSTALLATION N66-10260
- TEICH, M. C.**  
SILICON CONTROL RECTIFIER LONG PULSE DRIVER FOR  
INJECTION LASERS A65-30330
- TEMPLIN, H. A.**  
GREEN LASER LIGHT TRANSMISSION THROUGH WATER  
NOLTR-64-179 N65-20605
- TENG, H.-M.**  
FORMATION TIME OF OPTICAL LASER OSCILLATIONS  
N66-15050
- TENGROTH, B.**  
LASER IRRADIANCE LEVELS FOR RETINAL LESIONS  
A66-80011
- TER-MIKHAELIAN, M. L.**  
CONTINUOUS REGIME OPTICAL GENERATOR OUTPUT,  
THRESHOLD PUMPING LEVEL, INVERSE POPULATION  
DENSITY AND INDUCED RADIATION ENERGY A65-20326
- INTERNAL LOSSES EFFECT ON RADIATION POWER IN LASER  
A65-24058
- TEREKHIN, D. K.**  
LONGITUDINAL MAGNETIC FIELD EFFECT UPON GAS  
DISCHARGE, ZEEMAN EFFECT AND FARADAY EFFECT IN  
HE- NE GAS LASER A66-24224
- TERENTEV, V. E.**  
POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY  
ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR  
A65-36058
- POWERFUL PULSE OF RUBY LASER EMISSION GENERATED BY  
ULTRASONIC TRAVELING WAVE DIFFRACTION MODULATOR  
A66-15861
- TERHUNE, R. W.**  
NONLINEAR OPTICAL EFFECTS IN CRYSTALLINE AND  
ISOTROPIC MATERIALS DUE TO INDUCED POLARIZATION  
THIRD ORDER IN ELECTRIC FIELD STRENGTH, USING  
GIANT PULSED LASER SOURCE A65-16863
- TESTERMAN, M. K.**  
LASER PROPERTIES RELEVANT TO MEASUREMENT OF  
PHYSICAL PARAMETERS - MAPPING VIBRATING SURFACE,  
FREQUENCY RESPONSE OF TRANSDUCER, SENSITIVE  
LEVEL, PRESSURE DETERMINATION, AND HOLOGRAMS  
NASA-CR-68235 N66-12860
- THOMPSON, B. J.**  
LASER FOG DISDRUMETER FOR MEASURING DROPLET SIZE  
IN FOG A65-17644
- COHERENT LASER LIGHT FOR CONVENTIONAL AND  
UNCONVENTIONAL PHOTOGRAPHIC SITUATIONS A66-22670
- THOMPSON, H. B.**  
STIMULATED COMPTON SCATTERING OF ELECTRONS BY  
LASER BEAM IS-1187 N66-20388
- THORN, R. S. A.**  
MICROMACHINING WITH PULSED HELIUM-NEON GAS LASER,  
NOTING EXPERIMENTAL TECHNIQUES, OPERATION AND  
APPLICATION A66-19734

- THORNTON, E.**  
HE-NE LASER INCORPORATED INTO ARM OF INTERFEROMETER USED TO MEASURE FRINGE SHIFT IN SMALL TRANSIENT PLASMA A66-13743
- MACH-ZEHNDER LASER INTERFEROMETER AS DIAGNOSTIC TOOL IN SHOCK TUBE EXPERIMENTS A66-23352
- THORNTON, J. R.**  
RAYLEIGH SCATTERING USING LASER LIGHT FOR DETERMINATION OF SCATTERING DENSITY OF ARGON, OXYGEN, AND NITROGEN R-135 N65-26127
- THORP, J. S.**  
MAGNITUDE OF ANISOTROPIC LINE BROADENING IN RUBY A66-13278
- TIBILOV, A. S.**  
PLASMA DECAY IN PULSE DISCHARGE OF HELIUM-NEON LASER GRAPHICALLY DEPICTED UNDER CONDITIONS OF GENERATION A65-31878
- PULSE-DISCHARGE PLASMA DECAY STUDIED BY OBSERVATION OF GENERATION PROCESSES IN HELIUM-NEON PULSE LASER A65-33584
- TIEN, P. K.**  
C M HIGH-POWER CARBON DIOXIDE-NITROGEN-HELIUM LASER OPERATION, NOTING HELIUM ADDITION A66-16754
- TITLE, R. S.**  
HIGH POWER GALLIUM-ARSENIC INJECTION LASER DIODES AD-621649 N66-13744
- TITTEL, K. F.**  
GAIN DELAY CHARACTERISTICS OF FOUR-LEVEL NEODYMIUM-DOPED PULSED GLASS-LASER OSCILLATOR-POWER AMPLIFIER CHAIN A65-16574
- TOBIAS, I.**  
OUTPUT OF SINGLE MODE GAS LASER IN AXIAL MAGNETIC FIELD STUDIED FOR INCREASE IN FREQUENCY STABILITY A65-26954
- TOMIYASU, K.**  
PHOTOGRAPHIC STUDY OF Q-SWITCHED LASER BEAM PROPAGATING OVER 10-MILE PATH A65-31044
- LASER BIBLIOGRAPHY / JUNE TO DECEMBER 1964/ A65-32749
- LASER BIBLIOGRAPHY COVERING DEVICES AND RELATED SYSTEMS FOR PERIOD JANUARY- JUNE 1965 A66-11372
- TOMLINSON, J. L.**  
HELIUM-NEON GAS LASER AS LIGHT SOURCE FOR MAGNETO-OPTICAL APPARATUS - KERR MAGNETO-OPTICAL EFFECT OF FERROMAGNETIC IRON-NICKEL THIN FILM N65-26766
- TOMLINSON, R. G.**  
OPTICAL SWITCH WHICH CUTS OFF LASER PULSE WHEN SELECTED BEAM POWER LEVEL IS REACHED A65-21626
- ATMOSPHERIC BREAKDOWN LIMITATIONS TO OPTICAL MASER PROPAGATION A66-14837
- VISIBLE DISCHARGES INDUCED IN GASES BY FOCUSED RUBY LASER PULSES REPT.-1579-14 N65-14982
- TEMPORAL DEPENDENCE IN LASER INDUCED GAS DISCHARGES REPT.-1935-2 N65-21555
- BREAKDOWN OF ARGON BY NEODYMIUM AND RUBY LASER PULSES REPT.-1935-1 N65-22072
- TRIGGERING OF BREAKDOWN OF NOBLE GASES SUBJECTED TO RUBY LASER RADIATION BY MULTIPHOTON IONIZATION REPT.-1935-3 N65-22851
- TONON, G.**  
ENERGY AND INTENSITY OF IONS EMITTED BY METAL TARGET AS FUNCTION OF CHARACTERISTICS OF LASER AND NATURE OF METAL A66-15109
- TORALDO DI FRANCIA, G.**  
QUASI-CONTINUOUS EMISSION OR REGULAR RELAXATION OSCILLATIONS FROM MANY-ELEMENT RUBY LASER OPERATING IN VERY FEW AXIAL MODES A65-19619
- FOCUSED LASER AS ACCELERATING CAVITY FOR CYCLIC PARTICLE ACCELERATOR A66-10328
- PEAK POWER TRANSIENTS OF NEAR CONFOCAL HELIUM-NEON LASER WORKING AT 6328 ANGSTROMS ON PULSED DISCHARGE BASIS A66-10329
- THEORETICAL STUDY OF RESONANT MODES OF LASER CAVITY WITH END MIRRORS AND PERIODIC REFLECTIVITY AFCRL-64-1015 N65-17931
- MICROWAVE MODELS OF OPTICAL RESONATORS - LASER OR MICROWAVE RESONATOR WITH FLAT ROOF MIRRORS - OPEN LASER RESONATORS RESEARCH AFCRL-65-568 N65-34155
- TOWNES, C. H.**  
MASERS AND LASERS, DISCUSSING COHERENT RADIATION BY ATOMS AND MOLECULES AND QUANTUM ELECTRONICS TECHNIQUES OF GENERATING ACOUSTIC OR ELECTROMAGNETIC SPECTRUM A65-31383
- MASER-LASER THEORY AND APPLICATION A65-32621
- HISTORY AND DEVELOPMENT OF MOLECULAR AMPLIFICATION BY STIMULATED EMISSION OF RADIATION, NOTING VARIOUS LASER TYPES A65-36095
- HISTORY AND DEVELOPMENT OF MOLECULAR AMPLIFICATION BY STIMULATED EMISSION OF RADIATION, NOTING VARIOUS LASER TYPES A66-15034
- COHERENTLY DRIVEN MOLECULAR VIBRATIONS AND LIGHT MODULATION - RAMAN SCATTERING BY MASER BEAM NASA-CR-58211 N65-14531
- THEORY AND APPLICATION OF MASERS AND LASERS - CESIUM, HELIUM-NEON, AND RUBY MASER OSCILLATOR SYSTEMS N65-31361
- STIMULATED BRILLOUIN SCATTERING OF INTENSE LASER LIGHT WITH BUILD-UP OF COHERENT HYPERSONIC WAVES IN LIQUIDS NASA-CR-58214 N65-33710
- DYNAMICS AND CHARACTERISTICS OF SELF-TRAPPING OF INTENSE LIGHT BEAMS NASA-CR-74030 N66-23765
- TOWNSEND, R. L.**  
THERMAL DISTORTION, EXPANSION AND SCATTERING IN RUBY AND GLASS LASER RODS DURING AND AFTER PUMP FLASH A65-35068
- TOYODA, K.**  
ELECTRON DENSITY AND COLLISION FREQUENCY MEASUREMENTS IN TRANSIENT OSCILLATION OF IR AND VISIBLE HELIUM-NEON LASERS TO DETERMINE RELATIONSHIP BETWEEN OSCILLATIONS AND PLASMA PARAMETERS A65-34806
- TOZER, B. A.**  
ION AND FREE ELECTRON PRODUCTION RATE STUDY IN GAS UNDER LASER BEAM ACTION A65-19727
- DENSE HIGH-TEMPERATURE HYDROGEN PLASMA PRODUCTION BY INTENSE LASER PULSE HEATING OF MAGNETICALLY CONTAINED PLASMA A65-29978
- TRANMELL, W. V.**  
LASER TECHNIQUE TO PHOTOGRAPH HYPERVELOCITY PROJECTILES IN FREE-FLIGHT RANGE A66-13248
- TREGUBOV, G. A.**  
FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS

- SYSTEMS, PRIMARILY LIGHT ABSORPTION AND ATMOSPHERIC SCATTERING A65-15349
- FOG EFFECT ON RANGE OF LASER BASED COMMUNICATIONS SYSTEMS, PRIMARILY LIGHT ABSORPTION AND ATMOSPHERIC SCATTERING A65-32353
- TREUTHART, R. L.**  
FUSED SILICA OUTPUT COUPLING COMPONENT FOR LASER SYSTEM, USING FRUSTRATED TOTAL INTERNAL REFLECTION CONFIGURATION A66-17287
- TRIAS, J. A.**  
STIMULATED EMISSION AT ROOM TEMPERATURE IN EUROPIUM CHELATE SOLUTION A65-21625
- TRKAL, V.**  
CAVITY TUNING OF AMMONIA MASERS BY PRESSURE AND ZEEMAN EFFECT MODULATION N65-26684
- TROITSKII, I. V.**  
GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM INCIDENT ON PLANE PARALLEL GLASS PLATE OF RESONATOR A65-18555
- VISUAL PERCEPTION OF INTENSE COHERENT IR RADIATION FROM GAS LASER A65-24083
- REFLECTION COEFFICIENT OF MIRRORS MEASURED ON OPERATING WAVELENGTH OF LASER IN WHICH THEY ARE USED A65-25589
- GAS LASER OUTPUT DEPENDENCE ON ANGLE OF BEAM INCIDENT ON PLANE PARALLEL GLASS PLATE OF RESONATOR A65-27148
- SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-31306
- SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-33352
- VISUAL PERCEPTION OF INTENSE COHERENT IR RADIATION FROM GAS LASER A65-34904
- TROITSKII, U. W.**  
REFLECTION COEFFICIENT OF MIRRORS MEASURED ON OPERATING WAVELENGTH OF LASER IN WHICH THEY ARE USED A66-11420
- TROITSKIY, YU. V.**  
VISUAL PERCEPTION OF INFRARED LASER EMISSION NASA-TT-F-9888 N66-22300
- TROSHIN, B. I.**  
SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-31306
- SPECTRAL PROPERTIES OF HELIUM-NEON TRAVELING WAVE LASER, EXAMINING QUESTION OF MODE DECOUPLING A65-33352
- TROXEL, L. M.**  
SUPERCONDUCTING MAGNET FOR VARIABLE BANDWIDTH TRAVELING WAVE MASERS, NOTING AMPLIFIER BANDWIDTH INCREASE VIA GAIN REDUCTION A66-21417
- TRUFFERT, A.**  
CARBON MONOXIDE AND DIOXIDE VIBRATIONALLY INDUCED IR EMISSION WITH POSSIBLE APPLICATIONS TO CONTINUOUS LASER EMISSION A65-22463
- CONTINUOUS GAS LASER BY DIRECT HF EXCITATION OF NITROUS OXIDE AND MIXTURE WITH ARGON IN CAVITY, NOTING PERFORMANCES A65-23273
- CONTINUOUS LASER EMISSION DUE TO VIBRATIONAL TRANSITIONS IN CARBON DIOXIDE AND NITROUS OXIDE MIXTURES EXCITED BY HF SOURCE A65-26292
- TSAL, Y.-S.**  
TRANSMISSION CHARACTERISTICS OF NEODYMIUM LASER N66-16812
- TSAREGRADSKII, V. B.**  
THERMAL AND SHOT NOISE EFFECTS ON AMPLITUDE AND FREQUENCY OSCILLATIONS OF MOLECULAR BEAM MASER A65-19682
- STEADY STATE OSCILLATIONS OF MOLECULAR BEAM LASER WITH INHOMOGENEOUS SINUSOIDAL FIELD IN RESONATOR A65-36561
- OSCILLATION OF MASER WITH SINUSOIDAL DISTRIBUTION OF RESONATOR FIELD ALONG AXIS OF MOLECULAR MOTION A66-11843
- TSIKUNOV, V. M.**  
GENERATION OF INDUCED LASER RADIATION IN PRESTATIONARY REGIME A66-17877
- TSUNEKANE, S.**  
SIMPLE SINGLE MODE HELIUM-NEON LASER WHOSE OUTPUT IS SUFFICIENT FOR INTERFEROMETRIC METROLOGY A65-22621
- TSURU, H.**  
OBSERVATIONS OF RADIO SOURCES AT 9.4 GC WITH 2.2 FOOT FAN BEAM OF 16-ELEMENT INTERFEROMETER AND MASER AMPLIFIER A65-28335
- TSURUMI, I.**  
RADIATIVE TRANSITION PROCESS IN EMISSION SPECTRUM OF GALLIUM ARSENIDE P-N JUNCTION LASER DIODES A65-34666
- TUCKER, J. W.**  
LASER RESEARCH DEALING WITH EFFECT OF PUMPING ON RUBY QUALITY, LANTHANUM FLUORIDE EXAMINATION, LARGE RUBY LASER RODS, DC OPERATION OF MERCURY TUBE, HOLOGRAMS, AND LASER PHYSICS NRL-MR-1604 N65-28920
- TULUB, A. V.**  
NONLINEAR ZEEMAN EFFECT FOR GAS LASER A66-19638
- TUNITSKII, L. N.**  
CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF HF DISCHARGE IN HELIUM-NEON LASER A66-10704
- CURRENT AND VOLTAGE DISTRIBUTION OVER LENGTH OF HF DISCHARGE IN HELIUM-NEON LASER A66-23309
- TURKOV, I. G.**  
CONTINUOUS REGIME OPTICAL GENERATOR OUTPUT, THRESHOLD PUMPING LEVEL, INVERSE POPULATION DENSITY AND INDUCED RADIATION ENERGY A65-20326
- RUBY LASER THRESHOLD PUMPING AND EMISSION ENERGIES RELATED TO TRANSMISSION COEFFICIENT, ROD DIAMETER AND THRESHOLD LEVEL A65-20343
- INTERNAL LOSSES EFFECT ON RADIATION POWER IN LASER A65-24058
- PARASITIC INTERNAL OSCILLATIONS IN LASER CRYSTAL WITH DIELECTRIC ROD CAUSED BY TOTAL REFLECTION FROM GENERATRIX OF CYLINDRICAL SAMPLE A66-22739
- TURNER, R.**  
GAS CONSTITUTION OF HELIUM-NEON LASER DISCHARGE ANALYZED, CONSIDERING SPECTRUM LINE RELATIVE INTENSITIES IN LIGHT EMITTED FROM DISCHARGE TUBE A65-30333

## U

- UCHIDA, H.**  
OBSERVATIONS OF RADIO SOURCES AT 9.4 GC WITH 2.2 FOOT FAN BEAM OF 16-ELEMENT INTERFEROMETER AND MASER AMPLIFIER A65-28335
- UCHIDA, T.**  
FREQUENCY SPECTRA MEASUREMENT OF GASEOUS LASER BY PHOTOMIXING TECHNIQUES AND NOISE DISTRIBUTION A65-16405
- GAS LASER DIRECT MODULATION A66-18355



- UCHIKURA, K.  
UPPER ATMOSPHERIC OBSERVATION USING NORMAL-PULSE  
RUBY LASER TECHNIQUES, PRESENTING HEIGHT  
DISTRIBUTION CURVES OF SCATTERED LIGHT  
A66-13376
- UDOVENCHIK, V. T.  
LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING  
FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM  
ION IN VARIOUS CONCENTRATIONS  
A65-24881
- LUMINESCENCE AND ABSORPTION SPECTRA OF LASER USING  
FLUORITE CRYSTAL CONTAINING BIVALENT DYSPROSIUM  
ION IN VARIOUS CONCENTRATIONS  
A65-36358
- UEHARA, K.  
HIGHER ORDER CALCULATION OF LASER OUTPUT, NOTING  
APPROXIMATION METHOD FOR LINewidth PARAMETER AND  
LAMB DIP SHAPE ACCURACY  
A66-19063
- UGLOV, A. A.  
HEATING PROCESS IN LASER WELDING OF METAL SHEETS,  
TAKING INTO ACCOUNT ENERGY DISTRIBUTION, HEAT  
TRANSFER AND FLUX DENSITIES  
A66-15347
- UNTERLEITNER, F. C.  
RUBY LASER MODULATION AT ATOMIC LEVEL - FREQUENCY  
SHIFT MEASUREMENT OF LASER EMISSION UNDER  
INHOMOGENEOUS MAGNETIC FIELD BY SPECTROSCOPY  
NASA-CR-57464  
N65-19863
- LASER MODULATION AT ATOMIC LEVEL - YTTRIUM-  
ALUMINUM GARNET EMISSION AND LASER EMISSION  
SHIFT WITH HOMOGENEOUS PULSED MAGNETIC FIELD  
NASA-CR-57823  
N65-21308
- MEASUREMENT OF TEMPERATURE DEPENDENCE OF ENERGY  
LEVELS INVOLVED IN LASER EMISSION  
NASA-CR-64436  
N65-32191
- UNTERLEITNER, F. C., SR.  
LASER MODULATION AT ATOMIC LEVEL - POPULATION  
INVERSION AND ESTIMATE OF ZEEMAN SPLITTING  
NASA-CR-60572  
N65-16320
- UPATNIEKS, J.  
COHERENT LASER LIGHT USED IN NEW PHOTOGRAPHIC  
PROCESS FOR RECORDING LIGHT WAVES INSTEAD OF IMAGE  
ON LIGHT-SENSITIVE FILM  
A65-28104
- URTIEN, P. A.  
ONSET OF RETONATION, LASER TECHNOLOGY AND HIGH  
REpetition-HIGH RESOLUTION SCHLIEREN STROBOSCOPIC  
WAVE PHENOMENA RECORDS  
A66-19200
- USPENSKII, A. V.  
EXCITATION OF AXIAL OSCILLATION MODES IN  
SEMICONDUCTOR LASERS ANALYZED, BASED ON RATE  
EQUATIONS FOR CHEMICAL POTENTIALS OF CARRIERS AND  
NUMBER OF PHOTONS  
A66-24455
- PULSED INDUCED EMISSION IN HYDROGEN BEAM LASER FOR  
CASE OF TWO RELAXATION TIMES, DETERMINING  
POLARIZATION ONLY BY NUMBER OF ACTIVE PARTICLES IN  
RESONATOR  
A66-24884
- V
- VAHER, E. O.  
OPTICAL FREQUENCY TRANSLATION TECHNIQUES LEADING  
TO DESIGN OF Y-SHAPED LASER CONFIGURATION  
AB-1272-0013  
N65-15259
- VALI, V.  
GIANT PULSE LASER USED FOR PRODUCTION OF PARTICLES  
WITH ENERGIES HIGHER THAN TEN BILLION EV  
A65-25877
- VALI, W.  
GIANT PULSE LASER USED FOR PRODUCTION OF PARTICLES  
WITH ENERGIES HIGHER THAN TEN BILLION EV  
A65-25877
- VALITOV, R. A.  
PULSE ENERGY AND POWER OF LASERS UNDER CONTINUOUS  
OPERATING CONDITIONS MEASURED, USING CALORIMETERS,  
PHOTOELECTRIC EFFECT OF RADIATION, ETC  
A66-13205
- VAN ALLEN, L. C.  
IONIZATION BREAKDOWN MECHANISMS OF GASES AT  
OPTICAL INFRARED FREQUENCIES USING LASERS  
RADC-TDR-64-422  
N65-18624
- VAN DEN BERG, C. B.  
POSSIBLE MATERIALS FOR SECOND HARMONIC GENERATION  
AND LASER ACTION DISCUSSING CENTROSYMMETRIC AND  
PIEZOELECTRIC CRYSTALS AND SINGLE CRYSTAL PLATE  
WITH ALTERNATE LAYERS OF NONCENTROSYMMETRIC  
COMPOSITION  
A66-12940
- VAN DER HOEVEN, C. J.  
GAS CONSTITUTION OF HELIUM-NEON LASER DISCHARGE  
ANALYZED, CONSIDERING SPECTRUM LINE RELATIVE  
INTENSITIES IN LIGHT EMITTED FROM DISCHARGE TUBE  
A65-30333
- VAN DER WAL, J.  
SMALL STABLE HELIUM-NEON LASER CONSTRUCTION AND  
MODE PATTERNS  
A65-21256
- VAN DER ZIEL, A.  
POWER DENSITY IN NOISE SIDEBANDS OF LASER CAUSED  
BY EMISSION NOISE IN ACTIVE MEDIUM  
A65-15321
- VAN HOPPE, S. J.  
SMALL STABLE HELIUM-NEON LASER CONSTRUCTION AND  
MODE PATTERNS  
A65-21256
- VAN TRAN, N.  
C-SWITCHED OPTICAL MASER SYNCHRONIZATION,  
DISCUSSING EXPERIMENTAL DESIGN, SETUP AND  
PERFORMANCE  
A66-17297
- VAN UITERT, L. G.  
LASER CHARACTERISTICS OF AND COHERENT OSCILLATIONS  
FROM TRIVALENT TM, HO, YB AND ER IONS IN  
YTTRIUM ALUMINUM GARNET  
A66-10241
- VAN MIJK, U.  
RUBY LASER OPTICAL RADAR DETECTION OF UPPER  
ATMOSPHERIC BACKSCATTERING  
A66-24395
- VANCE, M. E.  
SPECTRAL PUMPING EFFICIENCY, SOLARIZATION EFFECT,  
ENERGY OUTPUT, SPECTROSCOPY, GLASS DAMAGE AND  
OPTICAL PATH DISTORTIONS IN NEODYMIUM GLASS  
LASERS  
AD-612964  
N65-24195
- EFFECTS OF INTENSE ULTRAVIOLET RADIATION ON GLASS  
MATERIALS, AND PERFORMANCE CHARACTERISTICS OF  
GLASS LASERS  
AD-623309  
N66-14533
- VANDER SLUIS, K. L.  
INEXPENSIVE SIMPLIFIED CONSTRUCTION OF DC POWERED  
HELIUM NEON LASER WITH 6328 ANGSTROM OUTPUT  
A65-19849
- VANIER, J.  
HYDROGEN MASER CONSTRUCTION AND OPERATION DESIGN  
PRINCIPLES EMPHASIZING MICROWAVE CAVITY, LOW  
MAGNETIC FIELD, HYDROGEN STORAGE AND MASER TUNING  
TECHNIQUES  
A65-24309
- HYDROGEN MASER RESETTABILITY VERIFYING BY  
MEASURING MASER OUTPUT FREQUENCY AGAINST HYDROGEN  
PRESSURE, CONSIDERING EXCHANGE COLLISION AND WALL  
INTERACTIONS  
A65-29119
- CROSS CORRELATION MEASUREMENTS OF OSCILLATOR  
FREQUENCY STABILITY AND THERMAL NOISE AND  
APPLICATION TO ATOMIC HYDROGEN MASER  
A66-24128
- DIRECT FREQUENCY COMPARISON OF ATOMIC HYDROGEN  
MASERS IN DIFFERENT PLACES AND CONDITIONS BY  
SIMULTANEOUS MONITORING OF LORAN C SIGNALS  
A66-24145
- ATOMIC HYDROGEN MASER FOR TIME AND FREQUENCY  
MEASUREMENTS - TIME COMPARISONS ON MASERS WITH  
LORAN C  
N65-26678
- HYDROGEN MASER STORAGE BULB CHARACTERISTICS  
AD-617342  
N65-30159

## VANIUKOV, M. P.

EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS  
BY INCLINING GENERATING SAMPLE WITH RESPECT TO  
INTERFEROMETER AXIS A65-18454

EXCITATION OF OFF-AXIS STIMULATED RADIATION BEAMS  
BY INCLINING GENERATING SAMPLE WITH RESPECT TO  
INTERFEROMETER AXIS A65-28083

THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE  
LOSSES IN FABRY-PEROT RESONATORS DUE TO MIRROR  
MISALIGNMENT A65-36053

THRESHOLD PUMPING ENERGIES COMPARED TO DETERMINE  
LOSSES IN FABRY-PEROT RESONATORS DUE TO MIRROR  
MISALIGNMENT A66-15856

## VARNA, C. M.

THEORETICAL EXPLANATION FOR HIGHLY DIRECTIONAL  
OFF AXIAL RADIATION FROM SOLID STATE OPTICAL  
MASERS OF CIRCULAR CROSS SECTION  
TR-2 N65-34713

## VASILENKO, L. S.

VISUAL PERCEPTION OF INTENSE COHERENT IR  
RADIATION FROM GAS LASER A65-24083

EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE  
OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE  
A65-24084

VISUAL PERCEPTION OF INTENSE COHERENT IR  
RADIATION FROM GAS LASER A65-34904

EMISSION SPECTRUM OF NEON-HYDROGEN LASER FOR CASE  
OF HIGH CURRENT DENSITIES IN HOLLOW CATHODE  
A65-34905

VISUAL PERCEPTION OF INFRARED LASER EMISSION  
NASA-TT-F-9888 N66-22300

## VATULEV, V. M.

SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION  
PROPERTY CHANGES DUE TO PULSED RUBY LASER  
RADIATION A66-15354

## VAUTIER, P.

CARBON MONOXIDE AND DIOXIDE VIBRATIONALLY INDUCED  
IR EMISSION WITH POSSIBLE APPLICATIONS TO  
CONTINUOUS LASER EMISSION A65-22463

CONTINUOUS GAS LASER BY DIRECT HF EXCITATION OF  
NITROUS OXIDE AND MIXTURE WITH ARGON IN CAVITY,  
NOTING PERFORMANCES A65-23273

CONTINUOUS LASER EMISSION DUE TO VIBRATIONAL  
TRANSITIONS IN CARBON DIOXIDE AND NITROUS OXIDE  
MIXTURES EXCITED BY HF SOURCE A65-26292

## VAVILOV, V. S.

CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION  
A66-11188

FORCED EMISSION FROM ELECTRON-EXCITED CADMIUM  
SELENIDE A66-22174

CADMIUM TELLURIDE LASER WITH ELECTRON EXCITATION  
A66-24009

## VEDUTA, A. P.

CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL  
RUBY CRYSTALS DUE TO HEATING BY EXCITING LIGHT  
A65-18461

CHANGES IN EQUAL THICKNESS BANDS OF PLANE PARALLEL  
RUBY CRYSTALS DUE TO HEATING BY EXCITING LIGHT  
A65-28090

## VELGHE, M.

EVAPORATED CADMIUM SULFIDE THIN FILMS PROCESSED TO  
ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING  
LASER-INDUCED ELASTIC VIBRATION A65-31942

## VELGHE, M. F.

PROCESSING EVAPORATED CADMIUM SULFIDE THIN FILMS  
TO ACT AS PIEZOELECTRIC TRANSDUCERS FOR DETECTING  
LASER-INDUCED ELASTIC VIBRATIONS A65-21875

## VERBER, C. M.

TANTALUM ELECTRON INDUCED THERMIONIC EMISSION AS  
RESULT OF LASER BEAM BOMBARDMENT A65-24956

LASER BEAM INTERACTION WITH METAL FORM OF  
THERMAL, MULTIPLE PHOTON AND ELECTRIC FIELD EFFECT  
A65-27427

## VERDEYEN, J. T.

TIME RESPONSE OF HF LASER INTERFEROMETER USED IN  
PLASMA RESONANCE DETECTION A65-29791

QUANTUM-ELECTRONIC CROSS-MODULATION EFFECT NOTED  
WHILE MONITORING IR LASER INTERFEROMETRIC FRINGES  
A66-11449

LASER INTERFEROMETER AND APPLICATION TO PLASMA  
PHYSICS

AROD-4832-2 N65-17210

## VERET, C.

LASER USE IN LONG RANGE MEASUREMENT OF  
TRAJECTORIES  
ONERA TP 166 A65-19046

RANGE OF LASER TELEMETRIC DEVICE WITH REFLECTOR  
ON TRACKING OBJECT  
ONERA-TP-166/1964/ N65-28497

## VESSOT, R.

CROSS CORRELATION MEASUREMENTS OF OSCILLATOR  
FREQUENCY STABILITY AND THERMAL NOISE AND  
APPLICATION TO ATOMIC HYDROGEN MASER A66-24128

DIRECT FREQUENCY COMPARISON OF ATOMIC HYDROGEN  
MASERS IN DIFFERENT PLACES AND CONDITIONS BY  
SIMULTANEOUS MONITORING OF LORAN C SIGNALS  
A66-24145

## VESSOT, R. F. C.

HYDROGEN MASER CONSTRUCTION AND OPERATION DESIGN  
PRINCIPLES EMPHASIZING MICROWAVE CAVITY, LOW  
MAGNETIC FIELD, HYDROGEN STORAGE AND MASER TUNING  
TECHNIQUES A65-24309

HYDROGEN MASER RESETTABILITY VERIFYING BY  
MEASURING MASER OUTPUT FREQUENCY AGAINST HYDROGEN  
PRESSURE, CONSIDERING EXCHANGE COLLISION AND WALL  
INTERACTIONS A65-29119

ATOMIC HYDROGEN MASER FOR TIME AND FREQUENCY  
MEASUREMENTS - TIME COMPARISONS ON MASERS WITH  
LORAN C N65-26678

## VEYRIE, P.

PLASMA GENERATION BY FOCUSING LASER BEAM IN AIR AT  
ATMOSPHERIC PRESSURE AND ROOM TEMPERATURE INDICATE  
CONNECTION WITH LUMINOUS ENERGY ABSORPTION DURING  
BREAKDOWN A66-14538

ENERGY AND INTENSITY OF IONS EMITTED BY METAL  
TARGET AS FUNCTION OF CHARACTERISTICS OF LASER AND  
NATURE OF METAL A66-15109

IONIZATION UNDER LASER ACTION EXTENDED TO METALS  
AND DIELECTRICS, NOTING INFLUENCE ON THRESHOLDS  
A66-17065

## VIENOT, J. C.

SECOND HARMONIC EMISSION AND DIFFRACTION PHENOMENA  
IN KDP CRYSTAL EXCITED BY RUBY LASER BEAM  
A65-29559

## VINETSKII, V. L.

KINETIC EQUATION THEORY APPLIED TO STEADY STATE  
LASER RADIATION DUE TO BAND-BAND TRANSITION IN  
SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS  
A65-26694

QUASI-FERMI LEVEL, FREQUENCY, THRESHOLD PUMPING  
VALUE AND PARTICULAR MODE IN RADIATIVE INTRABAND  
TRANSITION A65-31884

KINETIC EQUATION THEORY APPLIED TO STEADY STATE  
LASER RADIATION DUE TO BAND-BAND TRANSITION IN  
SEMICONDUCTOR CONTAINING IMPURITY CAPTURE LEVELS  
A65-32952

- SEMICONDUCTOR LASER RADIATION BY DIRECT ZONE-TO-ZONE TRANSITIONS A66-14273
- QUASI-FERMI LEVEL, FREQUENCY, THRESHOLD PUMPING VALUE AND PARTICULAR MODE IN RADIATIVE INTRABAND TRANSITION A66-18361
- VOELKER, L. E.  
CONVENTIONAL FLOW VISUALIZATION USING LASER LIGHT SOURCE  
AIAA PAPER 66-127 A66-17104
- VOGEL, K.  
TRANSMISSION OF HIGH-POWER LASER LIGHT FOR DIELECTRIC TUBES AND RODS A65-29164
- REPLICA TECHNIQUES AND ELECTRON AND OPTICAL MICROSCOPY TO STUDY LASER IRRADIATED METAL SURFACES A66-18393
- VOLLNER, J.  
MEASUREMENT OF ELECTRON DENSITY OF GAS DISCHARGE PLASMA BY LASER INTERFEROMETER A66-16379
- VOLOSHIN, A. E.  
MEASURING DEVICE FOR PULSED LASER OUTPUT POWER USING BOLOMETER, AMPLIFIER AND OSCILLOSCOPE A66-13888
- VONPE, A. F.  
PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER A66-10262
- PENTACARBOCYANINE COMPOUND USED TO REDUCE MONOPULSE DURATION IN NEODYMIUM LASER A66-13307
- VON CUTFELD, R. J.  
PHONON INTERACTION IN CRYSTALS - TRANSIENTLY OPERATED ACOUSTIC MASER, INTERACTION OF PHONONS WITH IMPURITIES IN GERMANIUM AND SILICON, AND HEAT PULSES IN CRYSTALS  
QTR-7 N65-27746
- SIGNAL VELOCITY OF MASERS, AND MICROWAVE PHONON ATTENUATION AND PULSED HEAT RADIATION IN SINGLE CRYSTAL SEMICONDUCTORS  
REPT.-8 N65-36734
- VORONOV, G. S.  
SPATIAL DISTRIBUTION OF ELECTRICAL FIELD OBTAINED BY FOCUSING RADIATION OF RUBY LASER A66-10250
- HYDROGEN MOLECULE MULTIPHOTON IONIZATION, DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY RUBY LASER EMISSION A66-16517
- HYDROGEN MOLECULE MULTIPHOTON IONIZATION, DETERMINING PROBABILITY OF ABSORPTION, EFFECTED BY RUBY LASER EMISSION A66-20898
- MULTIPHOTON IONIZATION OF XENON ATOM IN POWERFUL ELECTRIC FIELD BY RUBY LASER RADIATION A66-21966
- VOROPAIEV, N. D.  
LASER MODE OPERATION IN PRESENCE OF RADIATION ABSORBING IMPURITY ANALYZED BY EXTENDED THOMSON TYPE SYSTEM A65-35930
- VYLEGZHANIN, D. N.  
PUMPING POWER FORMULA FOR DETERMINING CHARACTERISTICS OF CONTINUOUS WAVE AND PULSED LASERS A65-26687
- PUMPING POWER FORMULA FOR DETERMINING CHARACTERISTICS OF CONTINUOUS WAVE AND PULSED LASERS A66-15900
- W
- WACHTEL, J. M.  
INTERACTION OF ENERGETIC ELECTRONS WITH BOUNDED ELECTROMAGNETIC WAVES NEAR CYCLOTRON RESONANCE, NOTING PLASMA DIAGNOSTICS, MASER AND GAIN MECHANISM A66-13953
- WADA, J. Y.  
ELECTRON ENERGY SPECTRA IN NEON, XENON AND HELIUM-NEON LASER DISCHARGES, CALCULATING PRODUCTION AND DESTRUCTION RATE PARAMETERS A66-18354
- ELECTRON ENERGY SPECTRA IN GAS LASER DISCHARGES AND INVESTIGATION OF NEW DISCHARGE CONFIGURATIONS  
NASA-CR-67298 N65-35355
- WAGNER, P. R.  
SWITCHING CHARACTERISTICS OF NEGATIVE RESISTANCE DIODE DETERMINATION - INJECTION LASER  
REPT.-7 N65-27203
- WAGNER, W. G.  
GIANT PULSE LASER APPLIED TO NONLINEAR OPTICAL EFFECT OF STIMULATED RAMAN SCATTERING WITH REFERENCE TO EMISSION ANGLE MEASUREMENT TECHNIQUE A65-19996
- STIMULATED RAMAN AND BRILLOUIN SCATTERING FOR STOKES RADIATION PARALLEL TO LASER BEAM IN RECTANGULAR WAVEGUIDE A66-14901
- WAITE, T.  
BALANCED MIXER ACTION FOR OPTICAL HETERODYNING, USING MAGIC-T OPTICAL MIXER A66-24153
- WAKABAYASHI, J.  
DESIGN OF 8 MILLIMETER TRAVELING WAVE MASER FOR RADIO ASTRONOMY  
AD-619191 N65-35172
- WAKSBERG, A. L.  
OPTICAL RESONATOR EFFECTS ON POPULATION DISTRIBUTION IN HELIUM-NEON GAS LASERS DETERMINED FROM SIDE LIGHT MEASUREMENTS A65-21656
- WALDMAN, G. S.  
RATE EQUATION SOLUTIONS FOR Q-SPOILED AND PULSED TRANSMISSION MODE / PTM/ OPERATION OF THREE-LEVEL LASER A65-22933
- WALKER, B. J.  
WIDE TUNING RANGE L-BAND TRAVELING WAVE MASER NOTING SLOW WAVE STRUCTURE AND ISOLATOR MATERIAL A66-12441
- EXPERIMENTAL L-BAND TRAVELING WAVE MASER DEVELOPED WITH EXCEPTIONALLY WIDE TUNING RANGE A66-15958
- EASILY FABRICATED LIGHTWEIGHT SUPERCONDUCTING MAGNET DESIGNED FOR USE WITH TRAVELING WAVE MASERS A66-24312
- WALKER, J. M.  
LASER IN SPACE APPLICATION, DISCUSSING ELECTRO-OPTICAL DEVICES A65-31883
- WALKLEY, K.  
CONTINUOUS OUTPUT GAS-PHASE LASERS AS SMALL BANDWIDTH SOURCES OF LIGHT FOR OPTICAL DIFFRACTOMETERS A65-22206
- WALLACE, A.  
LASER BEAM COMMUNICATION BETWEEN DEEP-SPACE VEHICLE AND EARTH TRACKING STATION - CLOSED LOOP SYSTEM AND LEAD ANGLE COMPUTATIONS FOR TARGET MOTION COMPENSATION  
NASA-CR-60699 N65-16811
- WALLACE, R. A.  
OUTPUT OF SINGLE MODE GAS LASER IN AXIAL MAGNETIC FIELD STUDIED FOR INCREASE IN FREQUENCY STABILITY A65-26954
- WALLING, J. C.  
TRAVELING WAVE MASER FOR TELSTAR AND RELAY SATELLITES, DISCUSSING ELECTRONICS AND SOLID STATE PHYSICS PRINCIPLES AND DESIGN A65-16798
- WALSH, D.  
TIME RESOLUTION OF ELECTRON AND ION EMISSION PRODUCED BY Q-SWITCHED RUBY LASER PULSE FOCUSED ON METAL SURFACE A66-18358

- WALSH, J. L.**  
LASER CONFIGURATIONS, PERFORMANCE FEATURES AND LIMITATIONS DISCUSSING HE- NE, ION AND SOLID STATE LASERS A65-31881
- AMMONIA BEAM MASERS WITH ASSOCIATED FREQUENCY TRANSLATING CIRCUITRY NASA-CR-55839 N65-13558
- WALSH, M. J.**  
INSTRUMENTATION TECHNIQUES FOR NEW TYPE OF GAS DENSITY MEASURING SYSTEM USING LIGHT SCATTERED FROM LASER BEAM AS MEASURED QUANTITY A66-15794
- WALTER, W. T.**  
LASER ACTION ON FIVE GREEN LINES AND SIX IR LINES CAUSED BY PULSING MANGANESE DISCHARGE OF COLLISION LASER IN ATOMIC VAPOR OF NEUTRAL MANGANESE A66-16763
- WAN, C.-I.**  
STIMULATED EMISSION OF LIGHT FROM PURE XENON AND HELIUM-XENON N65-20135
- HELIUM-NEON LASER WITH SILVER AND DIELECTRIC COATING N65-20136
- WANDINGER, L.**  
GALLIUM ARSENIDE LASER DIODES WITH HIGH OUTPUT COHERENT BEAM FOR COMMUNICATIONS SYSTEMS ECOM-2629 N66-21293
- WANG, C.**  
OPTICAL PARAMETRIC AMPLIFICATION INVOLVING THREE WAVES, OPERATION OF HIGH POWER, NEARLY SINGLE MODED RUBY LASER, AND OBSERVATION OF PARAMETRIC INTERACTION AMONG RAMAN-SHIFTED LINES RADC-TDR-64-386 N65-14311
- PARAMETRIC AMPLIFICATION IN ADENOSINE DIPHOSPHATE USING SECONDARY HARMONIC PRODUCED BY RUBY LASER RADC-TDR-64-484 N65-18629
- WANG, C. C.**  
PARAMETRIC GAIN ACCOMPANYING PARAMETRIC AMPLIFICATION OF LIGHT BEAM BY SECOND HARMONIC FREQUENCY OF STIMULATED RADIATION FROM RUBY LASER ADP CRYSTALS A65-24280
- HIGH POWER LASER BEAM COLLINEARIZATION USING BIREFRINGENCE OF UNIAXIAL CALCITE CRYSTAL PRISM A65-25828
- SECOND HARMONIC LIGHT GENERATION, STRESSING SATURATION EFFECTS OCCURRING AT HIGH LASER POWER LEVELS, SOLVING NONLINEAR COUPLED MAXWELL EQUATIONS A66-11443
- WANG, C.-C.**  
RESONANT CAVITY, OSCILLATION AND RADIATION OUTPUT OF OPTICAL MASERS FTD-TT-64-1231/1626364 N66-11458
- WANG, C.-J.**  
STIMULATED EMISSION OF LIGHT FROM PURE XENON AND HELIUM-XENON N65-20135
- HELIUM-NEON LASER WITH SILVER AND DIELECTRIC COATING N65-20136
- WANG, C.-K.**  
INFLUENCE OF RESONANT CAVITY, XENON LIGHT, AND OTHER PARAMETERS ON RUBY LASER EMISSION ENERGY OUTPUT FTD-TT-64-1339/1626364 N66-11522
- WANG, J.-W.**  
FORMATION TIME OF OPTICAL LASER OSCILLATIONS N66-15050
- WANG, M.**  
HELIUM-NEON LASER PREAMPLIFIER SYSTEM FOR VERY HIGH GAIN TRANSITION AT 3.39 MICRON WAVELENGTH A65-21335
- WARD, J. H.**  
LASER FOG DISDROMETER FOR MEASURING DROPLET SIZE IN FOG A65-17644
- WARNOCK, A. C. C.**  
ELECTRON DENSITY MEASUREMENTS IN PLASMA PRODUCED BY COMBINATION OF RF AND VERY FAST THETA-PINCH DISCHARGES, USING GAS LASER INTERFEROMETER A65-29848
- TIME-DEPENDENT ELECTRON DENSITY VARIATION STUDIED IN FAST THETA-PINCH DISCHARGE, USING HE- NE GAS LASER INTERFEROMETER A65-29849
- WARSHAUER, D.**  
GAS LASERS - LEVEL POPULATION DEPENDENCES, LASER POWER OUTPUT, METASTABLE DENSITY MEASUREMENTS, AND PARAMETER CHANGE EFFECT ON MATHEMATICAL MODEL OF LASER SYSTEM S-740 N65-20002
- WARSHAW, S. I.**  
APPARATUS FOR FLUORIDATION OF HYDROXYL AND OXYGEN CONTAMINATED FLUORIDE COMPOUNDS, OBTAINING OPTICALLY CLEAR CRYSTALS WITH NO TYNDALL SCATTERING FOR LASER APPLICATION A66-18488
- WARTER, P. J., JR.**  
EMISSION AND ABSORPTION PROFILES FOR RUBY R SUB 1 LINES SHOW ABSENCE OF SIGNIFICANT STOKES SHIFT A65-17664
- WATANABE, Y.**  
PULSED RUBY LASER OUTPUT MEASUREMENT BY OPTICAL BOLCHMETER A65-18017
- FLUORESCENCE FROM CADMIUM SULFIDE EXCITED BY RUBY LASER COMPARED WITH PHOTOCONDUCTIVITY INDUCED BY ORDINARY GREEN LIGHT TO SUPPORT DOUBLE PHOTON ABSORPTION MECHANISM A65-34665
- WATKINS, L. S.**  
REDUCTION OF LOCKING FREQUENCY OF RING LASER BY MAKING TWO BEAMS ORTHOGONAL A65-19601
- WATSON, H. J.**  
RAYLEIGH SCATTERING USING LASER LIGHT FOR DETERMINATION OF SCATTERING DENSITY OF ARGON, OXYGEN, AND NITROGEN R-135 N65-26127
- WATSON, W. R.**  
OPTICAL PROPERTIES OF CHANGES IN GAS COMPOSITION IN DISCHARGE TUBE FOR HELIUM NEON LASER TR-64-257.10 N65-19952
- WATTEAU, J. P.**  
DIFFUSION OF LIGHT BY PLASMA ELECTRONS PRODUCED IN LABORATORY FOR VERY SMALL EFFECTIVE DIFFUSION AREA A66-21712
- WAYNANT, R. W.**  
PHOTOGRAPHIC FILM USED FOR QUANTITATIVE MEASUREMENTS OF INTENSITY DISTRIBUTION IN Q-SWITCHED LASER BEAM A66-14920
- IONIZATION BREAKDOWN MECHANISMS OF GASES AT OPTICAL INFRARED FREQUENCIES USING LASERS RADC-TDR-64-422 N65-18624
- WEAVER, L. A.**  
QUANTUM-ELECTRONIC CROSS-MODULATION EFFECT NOTED WHILE MONITORING IR LASER INTERFEROMETRIC FRINGES A66-11449
- WEBER, H.**  
TIME DEPENDENT EMISSION BEHAVIOR OF RUBY LASER DISCUSSING RATE EQUATIONS, Q-VALUE, OUTPUT POWER, STEADY STATE VALUES, ETC A66-14981
- WEBSTER, J. C.**  
LOW FREQUENCY MAGNETIC FIELD SENSOR - PROTON MASER ANTENNA DESIGN CONSTRUCTION AND PERFORMANCE RADC-TR-64-567 N65-32211
- WEEKLEY, R. E.**  
SPIRAL FRINGES IN INTERFERENCE PATTERN OF INTERFEROMETER WITH LASER ILLUMINATION AS INDICATION OF DISCONTINUITY IN WAVE FRONT OR GENERATING SURFACE A65-33430

- WEIDLICH, W.  
LASER SYSTEM COHERENCE PROPERTIES OF STATISTICAL  
OPERATOR R IN LIGHT FIELD, USING SCHROEDINGER  
EQUATION ASSUMING GLAUBER STATE A65-25265
- MASTER EQUATION FOR COMPLETE STATISTICAL OPERATOR  
OF SOLID STATE LASER ACCORDING TO QUANTUM  
MECHANICS A65-31773
- WEINER, R. B.  
DATA PULSED TRANSMISSION OVER ELECTRON-INJECTION  
LASER COMMUNICATION SYSTEM, USING CONTINUOUS WAVES  
A66-19934
- WEINBERG, E. H.  
OPACITY MEASUREMENT OF XENON FLASH TUBE - OPTICAL  
MASER NASA-CR-56917 N65-35256
- WEINER, D.  
GIANT PULSE LASER APPLIED TO NONLINEAR OPTICAL  
EFFECT OF STIMULATED RAMAN SCATTERING WITH  
REFERENCE TO EMISSION ANGLE MEASUREMENT TECHNIQUE  
A65-19996
- LONGITUDINAL MODE SELECTION IN GIANT PULSE LASER  
RESULTING IN SINGLE-MODE OUTPUT A65-30345
- OBSERVED AND PREDICTED EFFICIENCY OF CONVERSION OF  
RADIATION FROM GIANT PULSE RUBY LASER INTO  
STIMULATED RAMAN SCATTERING A65-32209
- WEING, Y.-S.  
FORMATION OF MICROWAVE MASER BY PUMPING OF LOW  
TEMPERATURE RUBY LASER N66-15049
- WEISER, K.  
SWITCHING CHARACTERISTICS OF NEGATIVE RESISTANCE  
DIODE DETERMINATION - INJECTION LASER  
REPT.-7 N65-27203
- WEISMAN, D. L.  
LASER SURVEILLANCE USING OPTICAL BEAM SCANNING FOR  
DETECTION OF SPACE SATELLITES AND BALLISTIC  
MISSILES RADC-TDR-63-557 N65-22210
- WEISS, P.  
SYSTEM FOR OPTICAL ACQUISITION AND TRACKING, AND  
LASER BEAM DEFLECTOR DEVICES - ELECTRO-OPTICAL  
TECHNIQUES FOR CONTROLLING DIRECTION OF LASER  
BEAM FLOW NASA-CR-64222 N65-30541
- PIEZOELECTRICALLY POWERED LASER BEAM WAVEGUIDE FOR  
ELECTRO-OPTICAL ACQUISITION AND TRACKING  
NASA-CR-68895 N66-17291
- WEITZ, S.  
RUBY LASER AMPLIFIER AT LIQUID-NITROGEN  
TEMPERATURE TREATED AS THREE-MEDIUM TRANSMISSION  
SYSTEM, NOTING GAIN CHANGE WITH NEGATIVE  
ATTENUATION A66-22867
- WELLER, J. F.  
LASER OSCILLATIONS AND SELF Q-SWITCHING,  
DISCUSSING PULSED FLASH-LAMP EXCITATION  
EXPERIMENTS WITH TRIPLY ACTIVATED CONFOCAL BARIUM  
CROWN GLASS ETALON A66-13980
- WELLING, H.  
OPTICAL PATH LENGTH CHANGE MEASURED THROUGH LASER  
RODS WITHIN PUMPING PERIOD BY INTERFEROMETRIC  
TECHNIQUE A66-11376
- WELLS, W. H.  
GAS MASER PUMP ANALOGOUS TO OPERATION OF HEAT  
ENGINE FOR EXCITING MASER ACTION IN FAR IR,  
DETAILING INTERACTION BETWEEN PURE ROTATIONAL  
STATES OF H CL AND HF A65-35312
- WEN, C. P.  
ELECTRON BEAM PUMPING OF NOBLE GAS ION LASER  
A66-10350
- WERNER, G. K.  
INEXPENSIVE SIMPLIFIED CONSTRUCTION OF DC POWERED  
HELIUM NEON LASER WITH 6328 ANGSTROM OUTPUT A65-19049
- WESSEL, G.  
RUBY AS SUBMILLIMETER MASER MATERIAL, NOTING  
RELAXATION TIME AND TEMPERATURE CRITERIA A65-26821
- WESTERMEIER, H.  
HIGH SYMMETRY OSCILLATIONS IN CONTINUOUS WATER  
COOLED SOLID STATE LASERS, SHOWING RELATION TO  
EXCITATION CONDITIONS A65-14185
- WHINNERY, J. R.  
BUILDUP AND DECAY TRANSIENT EFFECTS IN GAS LASERS  
DUE TO LIGHT ABSORPTION BY INSERTED LIQUID SAMPLES  
A65-15816
- WHITCHER, R. E.  
POLARIZATION EFFECTS IN RUBY LASER CONSISTING OF  
RIGHT-ANGLE ROOF-TOPPED ROD WITH C AXIS  
PERPENDICULAR TO ROOF EDGE, EXTERNAL MULTILAYER  
DIELECTRIC REFLECTOR AND HELICAL FLASH TUBE  
A65-29530
- WHITE, A. D.  
FREQUENCY STABILIZATION OF GAS LASERS, USING  
ATOMIC RESONANCE AND INTERFEROMETERS A66-18357
- MODE SUPPRESSION TECHNIQUES FOR GAS LASER SINGLE  
AXIAL MODE OPERATION FOR LARGE MIRROR SEPARATIONS  
A66-23093
- WHITE, D.  
OPTICAL BEAM DIVERGENCE OF 6943 ANGSTROM LIGHT  
CAUSED BY SINGLE PASS THROUGH RUBY LASER AMPLIFIER  
DURING PUMPING A65-29529
- WHITE, G. R.  
LASER TYPES AND THEIR APPLICATION IN RADAR,  
INSTRUMENTATION, NAVIGATION AND COMMUNICATIONS  
A65-24131
- WHITE, J. A.  
STABILITY AND SOLUTION OF EQUATIONS OF MOTION FOR  
TRAVELING WAVE INTERACTIONS IN LASERS A65-19726
- WIDTH OF DECAY QUANTA IN GAS LASERS DEPENDS ON  
ENERGIES AND LIFETIMES OF ATOMIC LEVELS INVOLVED  
IN STIMULATED TRANSITIONS AND NONLINEAR RESPONSE  
OF ATOMS A66-12303
- WHITE, M. B.  
ATMOSPHERIC TURBULENCE EFFECT ON OPERATION OF  
DUAL-POLARIZATION FM LASER COMMUNICATION SYSTEM  
A65-33377
- WHITTEN, J. R.  
PHOTOGRAPHIC STUDY OF Q-SWITCHED LASER BEAM  
PROPAGATING OVER 10-MILE PATH A65-31044
- WICK, R. V.  
GAS SPECTROSCOPY OF LASER-INDUCED STIMULATED  
BRILLOUIN EFFECT IN HIGH PRESSURE OXYGEN  
A66-23432
- POWER AND PATH LENGTH EFFECTS ON STIMULATED RAMAN  
SPECTRA IN METHANE AND HYDROGEN STUDIES USING  
GIANT PULSED LASER N66-20037
- WIEDER, H.  
LASER DEFLECTION AND SCANNING BY MEANS OF  
MULTIMODE CAVITIES WITH DYNAMIC SPATIAL FILTERS  
A66-14829
- WIGGINS, T. A.  
POWER AND PATH LENGTH EFFECTS ON STIMULATED RAMAN  
SPECTRA IN METHANE AND HYDROGEN STUDIES USING  
GIANT PULSED LASER N66-20037
- WIGGINS, T. H.  
GAS SPECTROSCOPY OF LASER-INDUCED STIMULATED  
BRILLOUIN EFFECT IN HIGH PRESSURE OXYGEN  
A66-23432
- MILDEY, R. L.  
MOON SHAPE DETERMINED BY MEASURING DISTANCE FROM

- LUNAR SURFACE POINTS TO LUNAR CENTER OF MASS,  
USING OPTICAL LASER RADAR A66-22964
- WILKINSON, C. D. W.  
COHERENT LIGHT DIFFRACTION BY MICROWAVE SOUND IN  
TRANSPARENT CRYSTALS A65-29265
- WILLIAMS, O. W.  
GEODETIC SATELLITE, CALIBRATION SATELLITE, LASER  
GEODESY, AIRBORNE GRAVITY METER, LUNAR MOTION  
AND GRAVITY, AND BALLOON-BORNE LUNAR PHOTOGRAPHS  
AFCRL-65-14 N65-22221
- WILLIAMS, R. C.  
RECORDING SAMPLING SYSTEM FOR MEASURING ENERGY  
INCIDENT ON BIOLOGICAL SYSTEM EXPOSED TO LASER  
BEAM A66-17293
- WILLIAMS, R. M.  
SATELLITE-BORNE LASER ELECTRO-OPTICAL NAVIGATION  
SYSTEM, ANALYZING ANGULAR TRACKER AND CORNER-  
REFLECTOR SENSOR A65-29242
- WILLIAMSON, R.  
TIME CORRELATION BETWEEN LASER PULSES AND LASER-  
INDUCED ELECTRON EMISSION FROM METALLIC SURFACES  
A65-34616
- WILLIS, C. R.  
COHERENCE PROPERTIES OF INTERACTING SYSTEM OF  
RADIATION AND MATTER EXHIBITING LASER-LIKE  
BEHAVIOR, NOTING SELF-CONSISTENT-FIELD  
APPROXIMATION / SCFA/ USE FOR MANY-BODY EFFECTS  
A65-27725
- TWO-LEVEL ATOM INTERACTION WITH MULTIMODE GAS LASER  
CAVITY, OBTAINING STATIONARY STATE AND SOLVING  
UNIQUE EIGENVALUE IN SPECIAL CASES A66-24568
- WILLS, M. S.  
LASER OSCILLATIONS FROM PULSED ELECTRICAL  
DISCHARGE THROUGH NITROUS OXIDE AT 10.9 MICRON  
WAVELENGTH N65-20172
- LASER OSCILLATIONS AT WAVELENGTHS BETWEEN 21 AND  
32 MICRONS FROM PULSED DISCHARGE THROUGH AMMONIA  
N65-20173
- WILNOT, D. W.  
FEASIBILITY OF SINGLE-MODE MACROSCOPIC OPTICAL  
WAVEGUIDES AND COMPONENTS OPERATING AT  
MICROWAVE FREQUENCIES FOR ADVANCED LASER  
SYSTEMS NASA-CR-60527 N65-16252
- MACROSCOPIC WAVEGUIDE AND WAVEGUIDE COMPONENTS FOR  
OPTICAL SYSTEMS - LASERS NASA-CR-332 N66-16086
- WILSON, D. C.  
WAVELENGTH MEASUREMENT OF HELIUM-NEON LASER  
EMISSION BY DOUBLE-CHANNEL RECORDING  
INTERFEROMETER, USING KRYPTON-86 PRIMARY STANDARD  
A66-22874
- WILSON, D. K.  
OSCILLATION MODE CONTROL IN P-N JUNCTION LASERS  
FOR CURRENT DENSITY REDUCTION FOR STIMULATED  
EMISSION A66-17329
- WILSON, D. T.  
LASER OUTPUT SPIKING ELIMINATION USING KERR CELL  
CONTROLLED BY FEEDBACK CIRCUIT A65-24954
- WILSON, R. B., JR.  
GAS LASER, EXTERNAL SHUTTER TRIGGER CONTROL,  
MEDIUM POWER LASER, Q-SWITCHING, AND AMPLIFIER  
FOR GEODETIC AND LUNAR SURVEYING  
AFCRL-65-196 N65-27084
- WINER, I. M.  
PULSED YTTRIUM-ALUMINUM GARNET NEODYMIUM LASER  
DEVICE - SOLID STATE LASER DEVICE  
QPR-9 N66-14725
- WINOCUR, J.  
WAVELENGTH CHANGE OF SPONTANEOUS AND STIMULATED  
EMISSION WITH UNIAXIAL PRESSURE UNDER CW
- OPERATION OF GA AS DIODE LASER AT 4 DEGREES K  
A66-19922
- WOLF, E.  
INTEGRAL REPRESENTATION FOR ELECTROMAGNETIC FIELD  
IN FOCAL REGION OF COHERENT LIGHT BEAM EMERGING  
FROM APPLANATIC OPTICAL SYSTEM A65-27092
- WOLFE, A. L.  
USE OF LASER BEAM IN SPECTROGRAPHIC ANALYSIS -  
NORMAL LASER AND GIANT SPIKE LASER  
AFCRL-65-586 N66-12799
- WOLFE, C. M.  
DIRECT-INDIRECT TRANSITION EFFECT ON HALL EFFECT  
IN GALLIUM /ARSENIC PHOSPHIDE/ A66-21570
- GROWTH OF GALLIUM ARSENIDE-PHOSPHIDE COMPOUNDS  
FOR LASER USE  
AFCRL-65-271 N65-27833
- WOLGA, G. J.  
SILICON CONTROL RECTIFIER LONG PULSE DRIVER FOR  
INJECTION LASERS A65-30330
- WOODALL, J.  
OPTICAL GAIN AND LOSSES OF GA AS LASER OF  
EPITAXIAL AND DIFFUSED TYPE A65-33380
- WOODBURY, E. J.  
PULSED XENON FLASHLAMP AND CONTINUOUS INCANDESCENT  
TUNGSTEN LAMP TRADEOFFS AS NEODYMIUM-YTTRIUM  
ALUMINUM GARNET CRYSTAL LASER PUMPS  
REPT.-3 N65-30242
- PULSED LASER OSCILLATOR - ADVANCED DEVELOPMENT  
MODEL  
ECOM-00326-4 N66-12398
- WOODBURY, H. M.  
SEMICONDUCTOR DEVICES - SELENIUM DIFFUSION,  
CRYSTAL SYNTHESIS AND P-N JUNCTION FABRICATION,  
FREQUENCY MODULATION LASERS, AND GALLIUM  
COMPOUND INGOTS FOR LASER APPLICATION  
AFCRL-64-1007 N65-23135
- WOODCOCK, R.  
YB3- ER3 GLASS THREE LEVEL LASER ACTION  
A65-17208
- WOODCOCK, R. F.  
EFFECT OF COMPOSITION ON THERMAL EXPANSION  
COEFFICIENT, THERMAL COEFFICIENT OF REFRACTIVE  
INDEX, BIREFRINGENCE, AND STRESS-OPTICAL  
COEFFICIENTS FOR ATHERMALIZING LASER GLASS  
TSR-5 N65-25688
- WRIGHT, G. B.  
INDIUM ARSENIDE DIODE SPONTANEOUS AND LASER  
ELECTROLUMINESCENCE IN MAGNETIC FIELDS  
A65-24961
- WRIGHT, J. K.  
DENSE HIGH-TEMPERATURE HYDROGEN PLASMA PRODUCTION  
BY INTENSE LASER PULSE HEATING OF MAGNETICALLY  
CONTAINED PLASMA A65-29978
- WRIGHT, R. W. H.  
LOWER ATMOSPHERIC DENSITY MEASUREMENTS THROUGH  
LIGHT SCATTERING FROM Q-SPOILED RUBY LASER BEAM,  
USING OPTICAL RADAR DETECTOR A66-20398
- WRIGLEY, W. B.  
OPTICAL DATA PROCESSING TECHNIQUES CONSIDERING  
STORAGE, MANIPULATION, HOLOGRAPHY AND PATTERN  
RECOGNITION USING MATCHED FILTERS  
A66-12997
- WUERKER, K. F.  
SOLID-STATE LASER SYSTEM AS RADIATION PULSE  
GENERATOR  
STL-4127-6004-SU-000 N65-33686
- WUERKER, R. F.  
HIGH SPEED PHENOMENA HOLOGRAMS PRODUCED BY  
RADIATION FROM PULSED RUBY LASER OPERATED EITHER  
IN Q-SWITCHED OR CONVENTIONAL MODE  
A65-35067

- FAST HIGH RADIANCE ABLATING LASER PUMP AND ENERGY STORAGE TECHNIQUE  
AFAL-TR-65-22 N65-22702
- MYRAN, C. L.  
OPTICAL RENDEZVOUS GUIDANCE SYSTEM AND GROUND BASED OPTICAL TRACKING SYSTEM DEVELOPMENT N66-23458
- MYNANT, R. M.  
LASER BEAM DIVERGENCE AND ENERGY DISTRIBUTION MEASUREMENT, USING WIDE LATITUDE FILM AND THIN CELLULOID MIRROR A65-17432
- Y**
- YAJIMA, T.  
OPTICAL MIXING OF NITROBENZENE RAMAN RUBY LASER LIGHT IN ADP AND OTHER NONLINEAR DIELECTRIC MEDIA A65-15951
- YAKUBOVICH, YE. I.  
STEADY STATE OSCILLATIONS OF LASERS WITH DISTRIBUTED ENERGY LOSSES N65-27236
- YAMAMOTO, M.  
FABRY-PEROT MULTILAYER LASER AMPLIFIER SOLUTIONS FROM TRANSIENT THEORY POINT OF VIEW, USING LAPLACE TRANSFORM A65-29926
- YAMAMOTO, M.  
HE-NE GAS LASER APPLICATION TO SCHLIEREN PHOTOGRAPHY AND MACH-ZEHNDER INTERFEROMETRY IN AERODYNAMIC TESTING A65-22501
- NEON-HELIUM GAS LASER APPLICATION TO SCHLIEREN PHOTOGRAPHY AND MACH-ZEHNDER INTERFEROMETRY FOR USE IN AERODYNAMIC TESTING N65-21372
- YAMANAKA, C.  
ELECTRON DENSITY AND COLLISION FREQUENCY MEASUREMENTS IN TRANSIENT OSCILLATION OF IR AND VISIBLE HELIUM-NEON LASERS TO DETERMINE RELATIONSHIP BETWEEN OSCILLATIONS AND PLASMA PARAMETERS A65-34806
- YAMANAKA, M.  
MODE DEGENERACY-DIPS ON OUTPUT OF HE-NE LASER FOR CERTAIN CRITICAL COMBINATION OF MIRROR CURVATURES AND SEPARATION A65-36703
- YAMASHITA, T.  
OBSERVATIONS OF RADIO SOURCES AT 9.4 GC WITH 2.2 FOOT FAN BEAM OF 16-ELEMENT INTERFEROMETER AND MASER AMPLIFIER A65-28335
- YARIV, A.  
MULTIMODE LASER OSCILLATION RESULTING FROM MODULATION OF DIELECTRIC CONSTANT AND OF LOSS OR GAIN OF LASER MEDIUM A65-17652
- EQUATIONS OF MOTION GOVERNING INTERACTION OF OPTICAL MODES IN PRESENCE OF TIME-VARYING PARAMETERS A66-24559
- YASUDA, Y.  
SHORT-TERM FREQUENCY INSTABILITY AND FREQUENCY SPECTRA OF HIGHLY STABLE QUARTZ OSCILLATORS MEASURED, USING DOUBLE-BEAM AMMONIA MASER AS STANDARD A65-18320
- YASUOKA, Y.  
SINGLE FILAMENT JUNCTION LASER EMITTING COHERENT LIGHT OF SIMPLER MODES, SHOWING THAT LASER HAS TWO PORTIONS, EACH WITH SELECTIVE DIFFUSED REGION A66-21357
- YATSIV, S.  
STIMULATED RAMAN AND BRILLOUIN SCATTERING FOR STOKES RADIATION PARALLEL TO LASER BEAM IN RECTANGULAR WAVEGUIDE A66-14901
- YEE, J.  
LASER BEAM DEFLECTION MODULATION OBTAINED BY PASSING CURRENT THROUGH CADMIUM SULFIDE PRISM WITH OHMIC CONTACTS, USED FOR THERMOCOUPLE MEASUREMENTS A65-25890
- YEGOROV, V. P.  
AMMONIA MASER - AMMONIA MOLECULAR GENERATOR FTD-TT-65-803/16264 N66-19855
- YEN, H.-M.  
SEPARATION OF SINGLE WAVE OSCILLATION MODES OF NEON-HELIUM GAS LASER N65-20782
- YNGVESSON, S.  
L-BAND TRAVELING-WAVE MASER FOR RADIO ASTRONOMY RESEARCH AT 21 CM USES CHROMIUM-DOPED RUTILE A66-16640
- YODER, P. R., JR.  
LASER BEAM MODULATING TECHNIQUES AND SCANNING DEVICE TO FORM OPTIMAL VISUAL DISPLAYS RADC-TDR-64-365 N65-20562
- YOKOTA, R.  
FAR FIELD PATTERNS OF OFF-AXIAL MODES IN CYLINDRICAL GLASS NEODYMIUM LASER RODS A65-34807
- YOKOYAMA, M.  
MOBILE GAS MOLECULAR SCATTERING OF RUBY LASER LIGHT COMPARED WITH RAYLEIGH THEORY A65-15438
- YONEZU, H.  
SINGLE FILAMENT JUNCTION LASER EMITTING COHERENT LIGHT OF SIMPLER MODES, SHOWING THAT LASER HAS TWO PORTIONS, EACH WITH SELECTIVE DIFFUSED REGION A66-21357
- YOSHIDA, M.  
OPTICAL DESIGN OF ELLIPTICAL CAVITIES AND COMPARISON OF ENERGY TRANSFERS FROM LIGHT SOURCE TO RUBY LASER WITH CYLINDRICAL CAVITIES A66-16647
- YOSHIKAWA, S.  
OBSERVATIONS OF RADIO SOURCES AT 9.4 GC WITH 2.2 FOOT FAN BEAM OF 16-ELEMENT INTERFEROMETER AND MASER AMPLIFIER A65-28335
- YOSHIMURA, K.  
SHORT-TERM FREQUENCY INSTABILITY AND FREQUENCY SPECTRA OF HIGHLY STABLE QUARTZ OSCILLATORS MEASURED, USING DOUBLE-BEAM AMMONIA MASER AS STANDARD A65-18320
- YOSHINAGA, H.  
MODE DEGENERACY-DIPS ON OUTPUT OF HE-NE LASER FOR CERTAIN CRITICAL COMBINATION OF MIRROR CURVATURES AND SEPARATION A65-36703
- YOSHINO, K.  
FLUORESCENCE FROM CADMIUM SULFIDE EXCITED BY RUBY LASER COMPARED WITH PHOTOCONDUCTIVITY INDUCED BY ORDINARY GREEN LIGHT TO SUPPORT DOUBLE PHOTON ABSORPTION MECHANISM A65-34665
- YOUNG, C. G.  
ONE-WATT, ROOM TEMPERATURE, CONTINUOUS OPERATION, SUN PUMPED LASER TRANSMITTER AD-610601 N65-17927
- YOUNG, M.  
TRAVELING WAVE OSCILLATIONS IN RUBY LASER RESONATOR USING PASSIVE OPTICAL ISOLATOR, ELIMINATING FARADAY ROTATOR AND ATTENDANT MAGNETIC FIELD A66-11448
- YU, S.-S.  
SEPARATION OF SINGLE WAVE OSCILLATION MODES OF NEON-HELIUM GAS LASER N65-20782
- YURA, H. T.  
NONLINEAR ABSORPTION OF LASER RADIATION BY THREE-LEVEL ATOMIC SYSTEM RM-4478-PR N65-28654
- Z**
- ZAITSEV, IU. I.  
HELIUM-NEON LASER MULTIBEAM GENERATION IN GAS DISCHARGE TUBE, USING SPHERICAL MIRRORS AND TAPERED PLATES A65-24824
- PHASE RELATIONS OF LONGITUDINAL MODES IN GAS LASER

- WITH ANNULAR RESONATOR A66-10726
- ZAKHAROV, IU. P.**  
OPTICALLY CONNECTED LASER CONSTRUCTED ON GALLIUM ARSENIDE P-N JUNCTION, NOTING COHERENT RADIATION A66-14363
- GALLIUM ARSENIDE P-N JUNCTION LASER DIODE COVERING INJECTION CURRENT DISTRIBUTION, DENSITY AND EMISSION SPECTRA VARIATION A66-14659
- ZAKREVSKII, S. V.**  
SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION PROPERTY CHANGES DUE TO PULSED RUBY LASER RADIATION A66-15354
- SEMICONDUCTOR CRYSTALS, DISCUSSING DISPERSION PROPERTY CHANGES DUE TO PULSED RUBY LASER RADIATION A66-20895
- ZARE, R. N.**  
ATOMIC AND MOLECULAR FLUORESCENCE EXCITED BY PHOTODISSOCIATION, DISCUSSING LINE STRENGTH AND DOPPLER WIDTH A65-20073
- ZARGARIANTS, M. M.**  
CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION LASER COOLED BY HELIUM GAS FLOW A66-11190
- CONTINUOUS OPERATION OF GALLIUM ARSENIDE INJECTION LASER COOLED BY HELIUM GAS FLOW A66-24011
- ZAROVIN, C. B.**  
NEODYMIUM DOPED CALCIUM TUNGSTATE ROOM TEMPERATURE AMPLIFIER AND C W-LASER OSCILLATOR A65-18873
- POWER OUTPUT AND THRESHOLD POWER FOR CONTINUOUS WAVE NEODYMIUM-CALCIUM TUNGSTATE LASER IN RANGE OF DRY ICE TO ROOM TEMPERATURE A65-22619
- ZAYTSEV, YU. I.**  
MULTIBEAM GENERATION OF GASEOUS HELIUM-NEON LASER N65-27252
- ZEIDLER, G.**  
ROOM TEMPERATURE QUASI-CONTINUOUSLY PUMPED RUBY GIANT PULSE LASER WITH SATURABLE ABSORBER Q-SWITCH A66-21248
- ZEIGER, S. G.**  
INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY AFTER LEAVING LASER AND AFTER FOCUSING WITHIN LENS, NOTING OPTIMUM FOCUSING CONDITIONS A65-36050
- INTENSITY DISTRIBUTION OF RADIATION IMMEDIATELY AFTER LEAVING LASER AND AFTER FOCUSING WITHIN LENS, NOTING OPTIMUM FOCUSING CONDITIONS A66-15853
- ZELDOVICH, B. IA.**  
SPATIAL AMPLITUDE OF FIELD OF IDEALLY PARALLEL LASER BEAM FOCUSED BY OPTICAL SYSTEMS WITH SPHERICAL ABERRATION A66-23778
- ZELIKMAN, M. KH.**  
PUMPING POWER FORMULA FOR DETERMINING CHARACTERISTICS OF CONTINUOUS WAVE AND PULSED LASERS A65-26687
- PUMPING POWER FORMULA FOR DETERMINING CHARACTERISTICS OF CONTINUOUS WAVE AND PULSED LASERS A66-15900
- ZHELNOV, B. L.**  
INDUCED EMISSION MODES OF TRAVELING WAVE LASER A66-10778
- INDUCED EMISSION MODES OF TRAVELING WAVE LASER A66-22290
- ZHU, Z.-H.**  
PHOTON TRANSPORT AND POPULATION INVERSION IN ACTIVE MEDIUM WITH PUMPING EFFECT, CONSIDERING INTENSE BEAM INCIDENCE AND RUBY LASER A65-36712
- ZHUKOV, A. A.**  
TREATMENT OF STEEL WITH LASER BEAM, OBTAINING PRECISION HOLES WITHOUT AFFECTING MICROHARDNESS OF METAL A66-24898
- ZIETEMANN, H.**  
ELECTRON TEMPERATURE AND DENSITY MEASUREMENTS OF 26 K JOULE THETA-PINCH BY LIGHT SCATTERING FROM COMBINED OSCILLATOR-AMPLIFIER LASER IPP-1/42 N66-21141
- ZINGERY, W. L.**  
WAVELENGTH CHANGE OF SPONTANEOUS AND STIMULATED EMISSION WITH UNIAXIAL PRESSURE UNDER CW OPERATION OF GA AS DIODE LASER AT 4 DEGREES K A66-19922
- ZIPIN, R. B.**  
WAVELENGTH OF 3S2-2P4 TRANSITION OF NEON MEASURED, USING HELIUM-NEON LASER A66-16387
- ZIULKO, S. A.**  
LASER PROPERTIES, TECHNIQUES AND USES EMPHASIZING EMISSION MONOCHROMATICITY AND COHERENCE A65-32697
- ZOLOTOV, E. M.**  
RUBY LASER RADIATION EFFECT ON FLUORESCENCE AND LASER ACTION IN DYSPROSIUM DOPED CALCIUM FLUORIDE CRYSTALS A66-10718
- ZOOT, R. M.**  
VIGNETTING TEST FOR MIRROR TELESCOPE USING CW LASER A65-25826
- GAS LASER END REFLECTOR USING PELLIN-BROCA PRISM FOR SPECTRAL LINE SELECTION A66-20518
- ZUBAREV, I. G.**  
SELF-PULSED MODULATION MODE STABILIZATION OF TWO-LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE FEEDBACK A65-14144
- SELF-PULSED MODULATION MODE STABILIZATION OF TWO-LEVEL MASER BY AMPLITUDE CONTROL AND NEGATIVE FEEDBACK A65-24019
- EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF FORBIDDEN BAND IN GALLIUM ARSENIDE A65-31307
- EXCITING GALLIUM ARSENIDE BY NEODYMIUM-GLASS-LASER WHEN PUMPING PHOTON ENERGY IS LESS THAN WIDTH OF FORBIDDEN BAND IN GALLIUM ARSENIDE A65-33354
- GENERATION IN CADMIUM SULFIDE DURING TWO-PHOTON OPTICAL EXCITATION BY RUBY LASER WITH MODULATED Q-FACTOR A66-19620
- ZUBAREV, T. N.**  
TIME DEPENDENT VARIATION OF RUBY LASER STIMULATED EMISSION INTENSITY A65-19074
- TIME DEPENDENCY OF INTENSITY OF STIMULATED EMISSION IN RUBY LASER WITH OPTICAL RESONATOR CONTAINING ALUMINUM-COATED OPAQUE SPHERICAL MIRRORS A65-23014
- ZUBOV, V. A.**  
STIMULATED COMBINATION LIGHT SCATTERING WITHIN AND OUTSIDE RESONATOR CAVITY BASED ON LASER DEVELOPMENT A65-16627
- ZUEV, V. S.**  
INDUSTRIAL APPLICATION OF RUBY AND NEODYMIUM LASERS INCLUDE SUPERHARD MATERIAL MACHINING AND METALLURGY A65-18120
- TIME PARAMETERS OF POWERFUL LASER MEASURED WITH GA AS PHOTOCIDE, NOTING TIME CONSTANT AND TIME RESOLUTION OF PHOTOCIDE A65-34552
- LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION A65-35875
- HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM, NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION



PERSONAL AUTHOR INDEX

ZWEIG, H. J.

A65-35877

ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION  
IN NEODYMIUM GLASS LASER A65-36826

ELECTRO-OPTICAL SHUTTER FOR Q-FACTOR MODULATION  
IN NEODYMIUM GLASS LASER A66-13431

PROPAGATION RATE OF HIGH POWER LASER LIGHT PULSE  
IN INVERSELY POPULATED MEDIUM A66-15333

LASER WITH NEODYMIUM-GLASS Q-FACTOR MODULATION  
A66-18970

HEATING BY LASER BEAM WITH APPLICATION TO LITHIUM,  
NOTING USE FOR HIGH TEMPERATURE PLASMA PRODUCTION  
A66-18972

NONLINEAR AMPLIFICATION OF LIGHT PULSE PASSING  
THROUGH LASER OPERATING AT SATURATION REGIME  
A66-21963

ZUYEV, V. S.

ELECTRON BEAM MELTING HEAT SOURCE IN VACUUM  
METALLURGY, AND RUBY AND NEODYMIUM GLASS LASERS  
FOR INDUSTRY N65-23723

MASER DEVELOPMENT FROM INVERSIONAL TRANSITIONS IN  
HEAVY AMMONIA BEAM  
FTD-MT-64-330 N65-36869

ZWAS, F.

SPACE-TO-SPACE AND EARTH-TO-SPACE COMMUNICATION  
SYSTEMS USING LASER SOURCES  
RADC-TDR-64-289 N66-22582

ZWEIG, H. J.

TWO-DIMENSIONAL LASER DEFLECTION USING FOURIER  
OPTICS A66-10897